10063S

FINAL ANALYTICAL TAGA REPORT
HALBY CHEMICAL SITE
WILMINGTON, DELAWARE

JULY 1996

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1.0 INTRODUCTION

1.1 Objective

The United States Environmental Protection Agency/Environmental Response Team Center (U.S. EPA/ERTC) issued work assignment 1-170, Halby Chemical site, Wilmington, DE, to Roy F. Weston Inc. under the Response Engineering and Analytical Contract (REAC). An element of this work assignment was to investigate identified areas on the Halby Chemical site to determine potential soil/lagoon vapors and airborne concentrations of volatile organic compounds (VOCs) using the Sciex Trace Atmospheric Gas Analyzer (TAGA) 6000E in an effort to assist U.S. EPA Region III in its investigation to determine the site's impact to the environment and the general public via air emissions.

Ambient air monitoring for VOCs was conducted at identified areas downwind of the excavation activities on the Halby Chemical site. Monitoring was conducted during the period from 23-25 April 1996.

The TAGA was fitted with the low pressure chemical ionization (LPCI) source on 23 and 24 April 1996. Monitoring was performed using a selected ion technique to qualitatively and quantitatively identify the following compounds: benzene, toluene, xylenes, vinyl chloride, trichloroethene, tetrachloroethene, trans-1,2-dichloroethene, ethylthiocyanate, and ethylisothiocyanate. These compounds were selected based on information provided by the U.S. EPA Region III and availability of standards. In addition to the selected ion monitoring, parent ion and daughter ion spectra were collected when the TAGA was sampling downwind of the excavation activities to determine if other compounds were present.

The TAGA was fitted with the atmospheric chemical ionization (APCI) source on 25 April 1996. Parent ion and daughter ion spectra were collected when the TAGA was sampling downwind of the excavation activities to determine what compounds were present.

1.2 Background

The Halby Chemical site is approximately 13 acres in size and is located in Wilmington, New Castle County, Delaware. The triangular-shaped site is located in a highly industrialized area near the Port of Wilmington and is bordered by the Conrail Railroad to the northeast, Interstate 495 to the northwest, and Terminal Avenue to the south. Tidal freshwater wetlands associated with the Christina River lie adjacent to the eastern boundary of the site. An inactive chemical manufacturing facility and container storage area is presently in the southeastern portion of the site. A small (2.5 acres) area of degraded tidal wetlands, referred to by the owners as a lagoon, exists along a railroad bed in the northeastern portion of the site.

The Halby and Witco Chemical Companies produced sulfur compounds at the site from 1948 to 1977. Carbon disulfide, ammonia, alkalis, acids, and alcohols were used to produce thiocyanate, sulfides, hydrosulfide, thioglycolates, and thiodipropinates. Wastewater and cooling water from the production of these compounds were disposed of in the 2.5-acre lagoon, which drained into the Christina River via Lobdell Canal.

In the period between 1964 and 1972, production waste discharge was directed into the Wilmington sewer system and only cooling water was discharged into the lagoon. After 1972, production waste was again combined with cooling water, treated on site and then discharged into the lagoon. Presently, the lagoon receives runoff from railroad tracks on the northeast side of the site and is influenced to some degree by drainage from Interstate 495. It also receives flow from the floor drains within the chemical plant.

An investigation by the Delaware Department of Natural Resources and Environmental Control, the U.S. Fish and Wildlife Service, the U.S. EPA/ERTC, the U.S. EPA Region III, and REAC in December 1990 characterized soils, sediment, groundwater, and surface water on site and in the surrounding vicinity. Analytical results from the samples collected indicate contamination by VOCs, base neutral acid extractable compounds (BNAs), metals, and cyanide.

2.0 TAGA METHODOLOGY

2.1 Mass Spectrometer/Mass Spectrometer General Theory

The TAGA 6000E mass spectrometer/mass spectrometer (MS/MS) is a direct air sampling instrument capable of detecting, in real time, trace levels of many organic compounds in ambient air. The technique of triple quadrupole MS/MS is used to differentiate and quantitate compounds.

The initial step in the MS/MS process involves simultaneous chemical ionization of the compounds present in a sample of ambient air. The ionization produces either positive or negative ions by donating or removing one or more electrons. The chemical ionization is a "soft" ionization technique which allows ions to be formed with little or no structural fragmentation. These ions are called parent ions.

The parent ions with different mass-to-charge (m/z) ratios are separated by the first quadrupole (the first MS of the MS/MS system). The quadrupole scans selected m/z ratios allowing only the parent ions with these ratios to pass through the quadrupole. Parent ions with m/z ratios different than those selected are discriminated electronically and fail to pass through the quadrupole.

The parent ions selected in the first quadrupole are accelerated through a cloud of uncharged argon atoms which is being introduced normal to the ion path in the second quadrupole. A portion of the parent ions entering the second quadrupole fragment as they collide with the argon atoms. These fragmented ions are called daughter ions. This process, in the second quadrupole, is called collision induced dissociation (CID).

The daughter ions are separated according to their m/z ratios by the third quadrupole (the second MS of the MS/MS system). The quadrupole scans selected m/z ratios, allowing only the daughter ions with these ratios to pass through the quadrupole. Daughter ions with m/z ratios different than those selected are discriminated electronically and fail to pass through the quadrupole. Daughter ions with the selected m/z ratios are then counted by an electron multiplier. The resulting signals are measured in second (ICPS) for each parent/daughter ion pair selected. The intensity of the ICPS for each parent/daughter ion pair is directly proportional to the ambient air concentration of the organic compound that produced the ion pair.

All of the ions discussed in this report have a single charge. The m/z ratio of all of the ions discussed are equal to the ion mass [atomic mass units (amu)]. Therefore, the terms parent and daughter mass are synonymous with parent and daughter ion m/z ratio.

2.2 MS/MS Limitations and Interferences

The TAGA 6000E has certain limitations in alleviating interferences. The three basic types of interferences originate with: 1) ionization mechanism, 2) structural isomerism, and 3) water clustering. These three types of interferences are briefly discussed below.

2.2.1 Ionization Mechanisms

Ionization in the source is accomplished by three mechanisms: 1) charge transfer - resulting in a singly charged ion with an m/z ratio of the same value as its mass; 2) addition (protonation or an adduct formation) - resulting in a singly charged ion with an m/z ratio of a greater value than its mass; and 3) loss (neutral loss or hydride extraction) - resulting in a singly charged ion with an m/z ratio of a lesser value than its mass. Illustrations of the above are:

1. Charge transfer - simple aromatic compounds (e.g., benzene forms a 78 m/z parent ion from a molecule of mass 78 amu).
2. Addition - simple oxygenated or nitrogenated compounds (e.g., bis-2-chloroethylether forms a 143 m/z parent ion from a molecule of mass 142 amu).
3. Loss - certain simple chlorinated alkanes (e.g., 1,1-dichloroethane forms a 63 m/z parent ion from a molecule of mass 98 amu).

Interference can occur when a number of different ionization pathways are exhibited. A compound can produce a parent ion population in one or more of these states simultaneously (e.g., 1,1-dichloroethene forms a 98 m/z parent ion by charge transfer and a 99 m/z parent ion by proton addition).

2.2.2 Structural Isomerism

Structural isomers may produce the same parent ions. If the isomers are very similar, the daughter ions produced are the same and differ only in the ratios yielded. The result is that the compounds are indistinguishable by selected ion monitoring (e.g., xylene and ethyl benzene form a 106 m/z parent ion and 39, 51, 65, and 91 m/z daughter ions).

2.2.3 Water Clustering

Water clustering can produce ions that interfere with the determination of certain compounds. Water vapor can hydrate lower weight ions to form ions at m/z ratios equal to the nominal m/z ratios of the parent ions of trace organics that are not hydrated (i.e., a protonated ethanol water cluster $CH_3CH_2OH(H_3O)^+$ forms a parent ion with the same m/z 65 as 1,1-dichloroethane).

2.3 TAGA Procedure

2.3.1 TAGA Warm Up

At the beginning of each sampling day, the first and third quadrupoles were scanned for 30 minutes each, which readied the instrument electronically.

2.3.2 TAGA Mass Calibration

2.3.2.1 LPCI Source

At the beginning of each sampling day, a gas mixture containing trichloroethene and tetrachloroethene was introduced by a mass flow controller into the sample air stream and the tuning parameters for the first and third quadrupoles were optimized for sensitivity and mass assignment.

2.3.2.2 APCI Source

At the beginning of each sampling day, a vapor phase containing 2-ethoxyethylacetate was introduced by a syringe drive into the sample air stream and the tuning parameters for the first and third quadrupoles were optimized for sensitivity and mass assignment.

2.3.3 TAGA Response Factor Measurement

2.3.3.1 LPCI Source

The calibration system consisted of a regulated gas cylinder with a mass flow controller or an adjustable speed control syringe drive dispenser. The calibration system was used to generate the analytes' response factors (RFs), in units of second per parts per billion by volume (ICPS/ppbv), which were then used to quantify trace components in ambient air samples. The TAGA was calibrated for the target compounds twice each sampling period, before commencing sample analysis and at its conclusion.

The syringe, which contained a pure liquid standard, was regulated at preset flow rates and diluted with ambient air. The TAGA was calibrated for ethylisothiocyanate using the syringe drive method. The software utilized each analyte's vapor pressure, syringe speed, air sampling flow rate, and atmospheric pressure to calculate the analyte's RFs.

The gas cylinder, which contained a known mixture of target compounds certified by the supplier (Appendix A), was regulated at preset flow rates and diluted with ambient air. The dilution of a gas cylinder gave known analyte concentrations. The TAGA was calibrated for the target compounds, which were contained in cylinder SX-22629. The software utilized each analyte's cylinder concentration, gas flow rate, air sampling flow rate, and atmospheric pressure to calculate the analyte's RFs. The RFs were obtained for the ion pairs of each compound of interest in the cylinder.

2.3.3.2 APCI Source

No RF measurements were performed when the APCI source was utilized. Only qualitative compound identification was investigated.

2.3.4 Selected Ion Monitoring

2.3.4.1 LPCI Source

Ambient air monitoring was performed by placing the inlet of the Teflon™ hose, which was connected to the TAGA, in the immediate proximity, downwind of the excavation activities. Outside ambient air was continuously drawn through a 200-foot section of Teflon hose at a flow rate of approximately 1.5 liters per second (L/sec). The air then passed through a glass splitter where the pressure gradient between the mass spectrometer core and the atmosphere caused a sample flow of approximately 10 milliliters per minute (mL/min) into the ionization source through a heated transfer line. The flow into the LPCI source was manually controlled and adjusted so that the ionization source pressure was maintained at an optimum value, which is about 1 torr. The remaining air flow was drawn through the air motor and vented from the bus.

The TAGA performed ambient air monitoring in the parent/daughter ion monitoring mode. The intensity of each parent/daughter ion monitored by the TAGA, in turn, was recorded by the Plessey™ computer in a file on the hard disk. One set of measurements of all of the ions is called a sequence.

2.3.4.2 APCI Source

No selected ion monitoring was performed when the APCI source was utilized. Only qualitative compound identification was investigated.

2.3.6 LPCI and APCI Parent and Daughter Ion Spectra

Parent and daughter ion spectra were collected in an effort to qualitatively identify compounds during excavation activities. The parent ion spectra were collected as background subtracted spectra. The daughter ion spectra were not collected as background subtracted spectra.

Background subtracted parent ion spectra were collected by storing conventional mass scans, which were obtained at an upwind location, and subtracting them from a conventional mass scans, which were obtained at locations downwind of emission sources or from headspace samples. A conventional mass scan is a mode of operation in which quadrupole 1 is scanned across a chosen mass range while collision gas is not present in quadrupole 2 and quadrupole 3 is automatically set in total ion mode at the same mass as quadrupole 1. In this mode, the TAGA emulates a single quadrupole spectrometer.

Benzene chemical ionization technique was utilized during the collection of some of the background subtracted parent ion spectra when the APCI source was employed. This chemical ionization technique increases the ion population in the APCI source for certain compounds by providing a less energetic charge transfer mechanism and, therefore, offers an additional method of gaining chemical information.

Daughter ion spectra were collected at locations downwind of emissions sources or from headspace samples by scanning quadrupole 3 while quadrupole 1 was set to a specific mass, called the parent mass. A daughter mass scan is a mode of operation in which quadrupole 3 is scanned across a specified start mass to end mass range, generating a mass spectrum of all the daughter ions produced by the fragmentation of parent ions with the collision gas in quadrupole 2.

3.0 RESULTS

3.1 Graphical Presentation

Figures 1a-1c through 11a-11c and 13a-13c are graphical representations of the TAGA files. A graph of each target compound concentration is presented with ppbv plotted on the vertical axis, and time into the run, in minutes, on the horizontal axis.

3.2 Spectral Presentation

Figures 1d, 1e, 2d, 3d, 4d, 7d, 8d, 9d, 10d, 11d, 12a-12f, 13d, 14a, 15a, 15d-15g, and 15i-15o are graphical representations of the background subtracted parent ion TAGA files. A graph of each parent ion present above background is presented with second plotted on the vertical axis, and m/z ratios on the horizontal axis. Figures 1f-1l, 3e-3k, 7e-7p, 8e-8n, 11e-11o, 12g-12j, 13e-13m, 15b, 15c, and 15h are graphical representations of daughter ion TAGA files from parent ions observed in the respective parent ion background subtracted ion spectra.

4.0 DISCUSSION OF RESULTS

The TAGA was on site for analytical analyses from 23 April to 25 April 1996. On 23 April and 24 April 1996, the TAGA was fitted with the LPCI source, which detects hydrocarbons and chlorinated compounds. The TAGA was calibrated for common industrial chemicals and ethylisothiocyanate, which was determined to be a compound of interest by the U.S. EPA Region III Remedial Project Manager (RPM). On 25 April 1996, the TAGA was fitted with the APCI source, which detects oxygenated and nitrogenated compounds.

4.1 23 April 1996 - (LPCI Source)

Pit 1 - Figures 1a-1c illustrate the selected ion monitoring for the target compounds. All target compound concentrations are shown to be below their quantitation limits, with the exception of ethylisothiocyanate. The plot of the ethylisothiocyanate is the average of the three parent/daughter ion pairs (87/29, 87/45, and 87/59). The averages for each compound's parent/daughter ion pair concentration are used to provide the most realistic conservative values. After examining the individual ion concentrations for each of the parent daughter ion pairs, it was evident that only the 87/45 parent/daughter ion pair rose and the 87/29 and 87/59 parent/daughter ion pairs did not exhibit similar changes with respect to time. Therefore, the increase in plot of the concentration for ethylisothiocyanate was due to an interferant effecting the 87/45 parent daughter ion pair and not the compound, ethylisothiocyanate. Figure 1d and 1e are two background subtracted parent ion spectra collected downwind of Pit 1. Figures 1f-1l are daughter ion spectra of some of the major peaks observed in the background subtracted parent ion spectra. All of the daughter spectra reveal water clusters or hydrocarbon adducts of hydrocarbon fragment ions.

Pit 2 - Figures 2a-2c illustrate the selected ion monitoring for the target compounds. All target compound concentrations are shown to be below their quantitation limits, with the exception of ethylisothiocyanate. For the same reasoning stated for Pit 1, this elevated concentration was due to an interferant and not the compound, ethylisothiocyanate. Figure 2d is a background subtracted parent ion spectrum collected downwind of Pit 2. The major peaks observed were similar to those in the parent subtracted ion spectra collected at Pit 1. Therefore, no daughter ion spectra were collected.

Pit 3 - Figures 3a-3c illustrate the selected ion monitoring for the target compounds. All target compound concentrations are shown to be below their quantitation limits. Figure 3d is a background subtracted parent ion spectrum collected downwind of Pit 3. Figures 3e-3k are daughter ion spectra of some of the major peaks observed in the background subtracted parent ion spectra. All of the daughter spectra reveal water clusters or hydrocarbon adducts of hydrocarbon fragment ions.

Pit 4 - Figures 4a-4c illustrate the selected ion monitoring for the target compounds. All target compounds' concentrations are shown to be below their quantitation limits. Figure 4d is a background subtracted parent ion spectrum collected downwind of Pit 4. The background subtracted parent ion spectrum revealed limited information, and therefore, no daughter ion spectra were collected.

Pit 4 Extension - Figures 5a-5c illustrate the selected ion monitoring for the target compounds. All target compound concentrations are shown to be below their respective quantitation limits. No parent ion nor daughter ion spectra were collected.

Pit 1 Extension - Figures 6a-6c illustrate the selected ion monitoring for the target compounds. All target compound concentrations are shown to be below their quantitation limits. No parent ion nor daughter ion spectra were collected.

Pit 1 Extension - Hose in the Pit - Figures 7a-7c illustrate the selected ion monitoring for the target compounds. All target compound concentrations are shown to be below their respective quantitation limits, with the exception of ethylisothiocyanate. For the same reasoning stated above for Pit 1, this elevated concentration was due to an interferant not the compound, ethylisothiocyanate. Figure 7d is a background subtracted parent ion spectrum collected in Pit 1 Extension. Figures 7e-7p are daughter ion spectra of some of the major peaks observed in the background subtracted parent ion spectrum. All of the daughter spectra reveal water clusters or hydrocarbon adducts of hydrocarbon fragment ions.

Pit 2 Extension - Hose in the Pit - Figures 8a-8c illustrate the selected ion monitoring for the target compounds. All target compound concentrations are shown to be below their quantitation limits, with the exception of ethylisothiocyanate. For the same reasoning that was stated above for Pit 1, this elevated concentration was due to an interferant not the compound, ethylisothiocyanate. Figure 8d is a background subtracted parent ion spectrum collected in of Pit 2 Extension. Figures 8e-8n are daughter ion spectra of some of the major peaks observed in the background subtracted parent ion spectrum. All of the daughter spectra reveal water clusters or hydrocarbon adducts of hydrocarbon fragment ions.

Pit 3 Extension - Hose in the Pit - Figures 9a-9c illustrate the selected ion monitoring for the target compounds. All target compound concentrations are below their quantitation limits. Figure 9d is a background subtracted parent ion spectrum collected in Pit 3 Extension. The background subtracted parent ion spectrum revealed limited information, and therefore, no daughter ion spectra were collected.

Pit 4 - Hose in the Pit - Figures 10a-10c illustrate the selected ion monitoring for the target compounds. All target compound concentrations are shown to be below their respective quantitation limits. Figure 10d is a background subtracted parent ion spectrum collected in Pit 4. The background subtracted parent ion spectrum revealed limited information, and

Pit 4. The background subtracted parent ion spectrum revealed limited information, and therefore, no daughter ion spectra were collected.

Enlarged Pit 1 - Hose in the Pit - Figures 11a-11c illustrate the selected ion monitoring for the target compounds. All target compound concentrations are below their respective quantitation limits, with the exception of ethylisothiocyanate. For the same reasoning that was stated above for Pit 1, this elevated concentration was due to an interferant not the compound ethylisothiocyanate. Figure 11d is a background subtracted parent ion spectrum collected in Enlarged Pit 1. Figures 11e-11o are daughter ion spectra of some of the major peaks observed in the background subtracted parent ion spectrum. All of the daughter spectra reveal water clusters or hydrocarbon adducts of hydrocarbon fragment ions.

4.2 24 April 1996 - (LPCI Source)

Soil Sample at the Willow Tree Location - Figures 12a-12f are background subtracted parent ion spectra collected using various methods. Figures 12g-12j are daughter ion spectra of some of the major peaks observed in the background subtracted parent ion spectra. All of the daughter spectra reveal water clusters or hydrocarbon adducts of hydrocarbon fragment ions.

Pit 1 - Hose in the Pit - Figures 13a-13c illustrate the selected ion monitoring for the target compounds. All target compounds' concentrations are shown to be below their quantitation limits. Figure 13d is a background subtracted parent ion spectrum collected in Pit 1. Figures 13e-13l are daughter ion spectra of some of the major peaks observed in the background subtracted parent ion spectra. All of the daughter spectra reveal water clusters or hydrocarbon adducts of hydrocarbon fragment ions.

Soil Sample from BIO-7 - Figure 14a is a background subtracted parent ion spectrum collected from a sample headspace. The background subtracted parent ion spectrum revealed limited information, and therefore, no daughter ion spectra were collected.

4.3 25 April 1996 - (APCI Source)

Pit 1 - Figures 15a, 15d, 15e, 15f, 15g, 15i, 15j, 15k, 15l, 15m, 15n, and 15o are background subtracted parent ion spectra collected downwind from Pit 1 during excavation activities. Benzene chemical ionization technique was employed to collect background subtracted parent ion spectra illustrated in Figures 15j, 15k, and 15o. Figures 15b, 15c, and 15h are daughter ion spectra of some of the major peaks observed in the background subtracted parent ion spectra. Due to the limited information available from the daughter ion spectra, no compound identification was possible.

5.0 QUALITY ASSURANCE/QUALITY CONTROL

The compound parent/daughter ion pairs used are listed below along with the abbreviation (ID) identifying the compounds.

Compound	ID	Parent Mass/Daughter Mass
Vinyl Chloride	VNCL	62/27
Vinyl Chloride	VNCL	64/27
Benzene	BEN	78/39
Benzene	BEN	78/52
Toluene	TOL	92/39
Toluene	TOL	92/51
Ethylisothiocyanate	ETCN	87/29
Ethylisothiocyanate	ETCN	87/45
Ethylisothiocyanate	ETCN	87/59
1,2-Dichloroethene	DCE	96/61
1,2-Dichloroethene	DCE	98/61
1,2-Dichloroethene	DCE	98/63
Xylene	XYL	106/39
Xylene	XYL	106/51
Xylene	XYL	106/65
Xylene	XYL	106/91
Trichloroethene	TCE	130/95
Trichloroethene	TCE	132/95
Trichloroethene	TCE	132/97
Tetrachloroethene	PCE	164/129
Tetrachloroethene	PCE	166/129
Tetrachloroethene	PCE	166/131

The summaries of the actual and intermediate RFs (Section 5.1 and Tables 1 and 2) document the RFs generated during the calibration procedure for the individual ion pairs as well as the intermediate response factors used to quantitate the ion pair concentrations. The intermediate RFs are those factors which provide the average concentrations for an ion pair.

The summaries of detection and quantitation limit data for the sampling periods (Section 5.2 and Tables 3 and 4) document the ppbv concentration required for a compound's ion pair to be considered detectable and quantifiable during the specified sampling period. The detection limit is defined as three times the standard deviation of the concentration for a compound's ion pair measured in an ambient air sample. The quantitation limit is defined as 10 times the standard deviation of the concentration for the same conditions. Both the detection and quantitation limits are determined using an ambient air sample and the intermediate response factors.

The summaries of the target compound detection and quantitation limits measured during the sampling periods (Section 5.3 and Table 5) document the ppbv concentration required for the compounds to be considered detectable and quantifiable. The detection and quantitation limits for a compound result from averaging the detection and quantitation limits of the compound's ion pairs, as listed above. The potential maximum concentration percent deviation for the target compounds during the sampling periods (Section 5.4 and Table 6) are symmetrical measurements of the concentration variance resulting from daily response factor variability.

5.1 Calculations for the Actual and Intermediate Response Factor Summaries for the Sampling Periods

Response factors were generated from the initial and final calibration events, as described in the procedure. Tables 1 and 2 contain the RFs in units of ion counts per second/part per billion by volume (ICPS/ppbv). The actual RFs were used to calculate the intermediate RFs, which were used to calculate the concentrations reported in the results.

The following equation was used to calculate the intermediate response factors (IRF) found in Tables 1 and 2.

$$IRF = \frac{2\ (RF_1 \times RF_2)}{(RF_1 + RF_2)}$$

where:

IRF	=	Intermediate response factor (ICPS/ppbv)
RF_1	=	The RF for an ion pair measured during the initial calibration event (ICPS/ppbv)
RF_2	=	The RF for the same ion pair measured during the final calibration event (ICPS/ppbv)

For example, the entry for the 92/39 ion pair of toluene from Table 1 is:

RF_1	=	6.8 (ICPS/ppbv)
RF_2	=	5.9 (ICPS/ppbv)

and then,

$$IRF = \frac{2\ (6.8 \times 5.9)}{(6.8 + 5.9)} = \frac{80.4}{12.7} = 6.3\ ICPS/ppbv$$

5.2 Calculations for the Summaries of the Detection and Quantitation Limit Data for the Sampling Periods

The detection limits (DL) and quantitation limits (QL) were calculated using the standard deviation (SD) of the compound's ion pair intensity measured in an ambient air sample and its IRF, described earlier in this section.

The following equation was used to calculate the detection limits found in Tables 3 and 4.

$$DL = \frac{3 \times SD}{IRF}$$

where:

DL	=	Detection limit for an ion pair (ppbv)
SD	=	Standard deviation of the ion intensity for an ion pair measured in an ambient air sample (ICPS)
IRF	=	Intermediate response factor for an ion pair (ICPS/ppbv)

For example, the entry for the 92/39 ion pair of toluene from Table 3 is:

SD	=	16 ICPS
IRF	=	6.3 ICPS/ppbv

$$DL = \frac{3 \times 16}{6.3} = 7.6\ ppbv$$

The following equation was used to calculate the QL concentrations found in Tables 3 and 4:

$$QL = \frac{10 \times SD}{IRF}$$

where:

QL	=	Quantitation limit concentration for an ion pair (ppbv)
SD	=	Standard deviation of the ion intensity for an ion pair measured in an ambient air sample (ICPS)
IRF	=	Intermediate response factor for an ion pair (ICPS/ppbv)

For example, the entry for the 92/39 ion pair of toluene from Table 3 is:

SD	=	16 ICPS
IRF	=	6.3 ICPS/ppbv

$$QL = \frac{10 \times 16}{6.3} = 25.3\ ppbv$$

5.3 Calculations for the Summaries of the Target Compound Detection and Quantitation Limits for the Sampling Periods

The DLs and QLs for the target compounds found in Table 5 were generated by averaging the respective DLs and QLs of each target compound's ion pair found in Tables 3 and 4.

The following equation was used to calculate the compound's detection limit:

$$DL = \frac{DL_1 + DL_2 + \ldots + DL_n}{n}$$

where:

DL	=	Detection limit for a compound (ppbv)
DL_1	=	Detection limit for the first ion pair (ppbv)
DL_2	=	Detection limit for the second ion pair (ppbv)
DL_n	=	Detection limit for the nth ion pair (ppbv)
n	=	Number of ion pairs to be averaged

For example, using the entries for the 92/39 and 92/51 ion pairs of toluene from Table 3:

$$DL = \frac{7.6 + 5.7}{2} = \frac{13.3}{2} = 6.7\ ppbv$$

This number (6.7 ppbv) is the DL for toluene found in the Sampling Period of 04/23/96 column of Table 5.
The following equation was used to calculate the compound's quantitation limit.

$$QL = \frac{QL_1 + QL_2 + \ldots + QL_n}{n}$$

where:

QL	=	Quantitation limit for a compound (ppbv)
QL_1	=	Quantitation limit for the first ion pair (ppbv)
QL_2	=	Quantitation limit for the second ion pair (ppbv)
QL_n	=	Quantitation limit for the nth ion pair (ppbv)
n	=	Number of ion pairs to be averaged

For example, using the entries for the 92/39 and 92/51 ion pairs of toluene from Table 3:

$$QL = \frac{25.3 + 19.2}{2} = \frac{44.5}{2} = 22.3 ppbv$$

This number (22.3 ppbv) is the QL for toluene found in the Sampling Period of 04/23/96 column of Table 5.

5.4 Calculations for the Potential Maximum Concentration Percent Deviations for the Target Compounds for the Sampling Periods

The potential maximum concentration percent deviations presented in Table 6 are called "error bars" for simplicity. They represent the potential bias in the concentration due to changes in the sensitivity of the TAGA.

Error bars were calculated using the following equation:

$$error\ bars = \frac{|RF_1 - RF_2|}{(RF_1 + RF_2)} \times 100$$

where:

error bars	=	maximum concentration percent deviation (unitless)
RF_1	=	The RF for an ion pair measured during the initial calibration event (ICPS/ppbv)
RF_2	=	The RF for the same ion pair measured during the final calibration event (ICPS/ppbv)

The above calculation was repeated for each ion pair. The error bars for each compound's ions were averaged to give a single value for the compound. This error bar can be applied to the samples analyzed between the two calibrations of the sampling period.

For example, using the benzene data from Table 1 for the 92/39 ion pair:

RF_1 = 6.8
RF_2 = 5.9

and then

$$error\ bars = \frac{|RF_1 - RF_2|}{(RF_1 + RF_2)} \times 100 = \frac{|6.8-5.9|}{6.8+5.9} \times 100 = 7.0\%$$

7.0 percent is the error found for the 92/39 ion pair of toluene. For the other toluene ion pair, 92/51, the error bar is 5.5 percent. These ion pair error bars are averaged to give an error bar for toluene equal to 6.2 percent, which is the entry in Table 6.

Tables

TABLE 1
Actual and Intermediate Response Factors Summary for 23 April 1996
Halby Chemical Site
Wilmington, DE
July 1996

CALIBRATION TIME =>		07:51	18:37	INTERMEDIATE
ID	PM/DM	RESPONSE FACTOR	RESPONSE FACTOR	RESPONSE FACTOR
VNCL	62/27	46.29	46.97	46.63
VNCL	64/27	16.31	15.64	15.97
BEN	78/39	16.81	19.36	18.00
BEN	78/52	19.53	21.31	20.38
ETCN	87/29	60.67	57.95	59.28
ETCN	87/45	4.33	4.08	4.21
ETCN	87/59	23.99	25.27	24.61
TOL	92/39	6.80	5.91	6.32
TOL	92/51	11.60	10.40	10.96
DCE	96/61	39.78	38.41	39.09
DCE	98/61	13.99	13.49	13.74
DCE	98/63	13.57	12.92	13.24
XYL*	106/39	4.32	4.33	4.33
XYL*	106/51	2.24	2.32	2.28
XYL	106/65	6.12	5.27	5.66
XYL	106/91	25.14	18.73	21.46
TCE	130/95	24.37	21.60	22.90
TCE	132/95	8.80	8.12	8.45
TCE	132/97	14.97	14.36	14.66
PCE	164/129	19.80	14.33	16.63
PCE	166/129	7.15	5.67	6.33
PCE	166/131	17.29	12.88	14.77

*	=	Not used for quantitation - used for qualitative identification only
ID	=	Identification code
PM	=	Parent ion mass
DM	=	Daughter ion mass

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TABLE 2
Actual and Intermediate Response Factors Summary for 24 April 1996
Halby Chemical Site
Wilmington, DE
July 1996

CALIBRATION TIME =>		08:52 RESPONSE FACTOR	17:37 RESPONSE FACTOR	INTERMEDIATE RESPONSE FACTOR
ID	PM/DM			
VNCL	62/27	81.66	63.41	71.39
VNCL	64/27	25.36	22.52	23.86
BEN	78/39	25.60	24.83	25.21
BEN	78/52	30.86	29.08	29.94
ETCN	87/29	63.15	64.72	63.93
ETCN	87/45	5.05	5.32	5.18
ETCN	87/59	27.27	31.11	29.06
TOL	92/39	7.41	7.14	7.27
TOL	92/51	13.75	13.74	13.74
DCE	96/61	71.72	71.00	71.36
DCE	98/61	26.67	24.44	25.51
DCE	98/63	23.16	23.15	23.15
XYL*	106/39	3.50	3.28	3.39
XYL*	106/51	2.44	2.53	2.49
XYL	106/65	6.70	5.45	6.01
XYL	106/91	19.31	17.94	18.60
TCE	130/95	35.08	28.46	31.42
TCE	132/95	11.51	11.53	11.52
TCE	132/97	20.95	18.73	19.78
PCE	164/129	23.41	19.27	21.14
PCE	166/129	9.26	6.84	7.87
PCE	166/131	21.57	16.91	18.95

* = Not used for quantitation - used for qualitative identification only
ID = Identification code
PM = Parent ion mass
DM = Daughter ion mass

TABLE 3
Summary of Detection and Quantitation Limits Data for 23 April 1996
Halby Chemical Site
Wilmington, DE
July 1996

ID	PM/DM	IRF	EBAR	DL ICPS	QL ICPS	DL PPBV	QL PPBV	INTSY ICPS	SD ICPS
VNCL	62/27	46.63	0.0072	51	170	1.1	3.6	32	17
VNCL	64/27	15.97	0.0209	72	240	4.5	15.0	40	24
BEN	78/39	18.00	0.0704	57	190	3.2	10.6	31	19
BEN	78/52	20.38	0.0436	60	200	2.9	9.8	32	20
ETCN	87/29	59.28	0.0229	54	180	0.9	3.0	30	18
ETCN	87/45	4.21	0.0297	51	170	12.1	40.4	30	17
ETCN	87/59	24.61	0.0260	54	180	2.2	7.3	28	18
TOL	92/39	6.32	0.0700	48	160	7.6	25.3	31	16
TOL	92/51	10.96	0.0546	63	210	5.7	19.2	37	21
DCE	96/61	39.09	0.0175	45	150	1.2	3.8	23	15
DCE	98/61	13.74	0.0182	51	170	3.7	12.4	27	17
DCE	98/63	13.24	0.0247	51	170	3.9	12.8	27	17
XYL*	106/39	4.33	0.0003	54	180	12.5	41.6	25	18
XYL*	106/51	2.28	0.0185	51	170	22.4	74.6	27	17
XYL	106/65	5.66	0.0746	63	210	11.1	37.1	36	21
XYL	106/91	21.46	0.1461	81	270	3.8	12.6	55	27
TCE	130/95	22.90	0.0603	60	200	2.6	8.7	33	20
TCE	132/95	8.45	0.0398	60	200	7.1	23.7	30	20
TCE	132/97	14.66	0.0209	51	170	3.5	11.6	26	17
PCE	164/129	16.63	0.1603	63	210	3.8	12.6	38	21
PCE	166/129	6.33	0.1156	60	200	9.5	31.6	30	20
PCE	166/131	14.77	0.1462	51	170	3.5	11.5	38	17

* = Not used for quantitation - used for qualitative identification only
IRF = Intermediate response factor in ion counts per seconds per part per billion by volume (ICPS/PPBV)
ID = Identification code
EBAR = Error bar
PM = Parent ion mass
DM = Daughter ion mass
DL = Detection limit
QL = Quantitation limit
SD = Standard deviation
INTSY = Intensity

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TABLE 4
Summary of Detection and Quantitation Limits Data for 24 April 1996
Halby Chemical Site
Wilmington, DE
July 1996

ID	PM/DM	IRF	EBAR	DL ICPS	QL ICPS	DL PPBV	QL PPBV	INTSY ICPS	SD ICPS
VNCL	62/27	71.39	0.1258	63	210	0.9	2.9	36	21
VNCL	64/27	23.86	0.0594	90	300	3.8	12.6	65	30
BEN	78/39	25.21	0.0154	51	170	2.0	6.7	34	17
BEN	78/52	29.94	0.0297	72	240	2.4	8.0	36	24
ETCN	87/29	63.93	0.0123	81	270	1.3	4.2	42	27
ETCN	87/45	5.18	0.0258	72	240	13.9	46.3	40	24
ETCN	87/59	29.06	0.0657	63	210	2.2	7.2	35	21
TOL	92/39	7.27	0.0184	63	210	8.7	28.9	32	21
TOL	92/51	13.74	0.0003	66	220	4.8	16.0	36	22
DCE	96/61	71.36	0.0050	66	220	0.9	3.1	27	22
DCE	98/61	25.51	0.0436	54	180	2.1	7.1	29	18
DCE	98/63	23.15	0.0003	48	160	2.1	6.9	24	16
XYL*	106/39	3.39	0.0311	51	170	15.1	50.2	26	17
XYL*	106/51	2.49	0.0186	57	190	22.9	76.5	32	19
XYL	106/65	6.01	0.1022	54	180	9.0	29.9	28	18
XYL	106/91	18.6	0.0367	69	230	3.7	12.4	32	23
TCE	130/95	31.42	0.1042	69	230	2.2	7.3	29	23
TCE	132/95	11.52	0.0009	69	230	6.0	20.0	27	23
TCE	132/97	19.78	0.0561	51	170	2.6	8.6	31	17
PCE	164/129	21.14	0.0970	66	220	3.1	10.4	30	22
PCE	166/129	7.87	0.1509	57	190	7.2	24.2	27	19
PCE	166/131	18.95	0.1211	72	240	3.8	12.7	32	24

* = Not used for quantitation - used for qualitative identification only
IRF = Intermediate response factor in ion counts per seconds per part per billion by volume (ICPS/PPBV)
ID = Identification code; EBAR = Error bar
PM = Parent ion mass; DM = Daughter ion mass
DL = Detection limit; QL = Quantitation limit
SD = Standard deviation; INTSY = Intensity

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TABLE 5
Summary of Target Compounds Detection and Quantitation Limits
Measured on 23 April 1996 and 24 April 1996
Halby Chemical Site
Wilmington, DE
July 1996

	04/23/96		04/24/96	
COMPOUND	DL (PPBV)	QL (PPBV)	DL (PPBV)	QL (PPBV)
BEN	3.06	10.19	2.21	7.38
DCE	2.91	9.68	1.70	5.68
ETCN	5.08	16.93	5.78	19.26
PCE	5.57	18.58	4.72	15.74
TCE	4.40	14.67	3.59	11.96
TOL	6.67	22.24	6.73	22.44
VNCL	2.80	9.34	2.33	7.76
XYL	7.45	24.83	6.35	21.15

DL = Detection limit
QL = Quantitation limit
PPBV = Parts per billion by volume

TABLE 6
Summary of Potential Maximum Concentration Percent Deviations
for the Target Compounds on 23 April 1996 and 24 April 1996
Halby Chemical Site
Wilmington, DE
July 1996

COMPOUND	04/23/96	04/24/96
BEN	5.70	2.25
DCE	2.01	1.63
ETCN	2.62	3.46
PCE	14.07	12.30
TCE	4.03	5.37
TOL	6.23	0.94
VNCL	1.41	9.26
XYL	11.04	6.95

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Figures

Figures

ORIGINAL
(Red)

23 April 1996

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Pit 1

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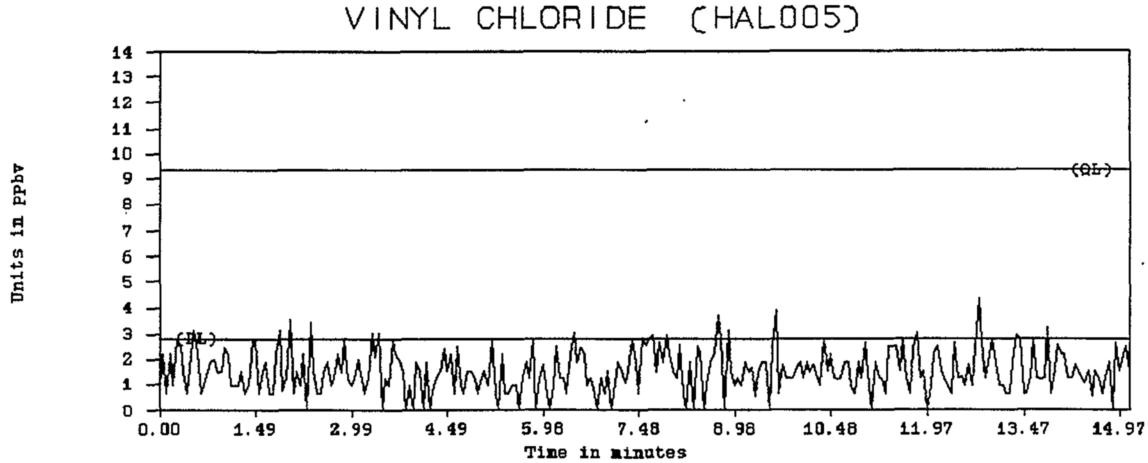
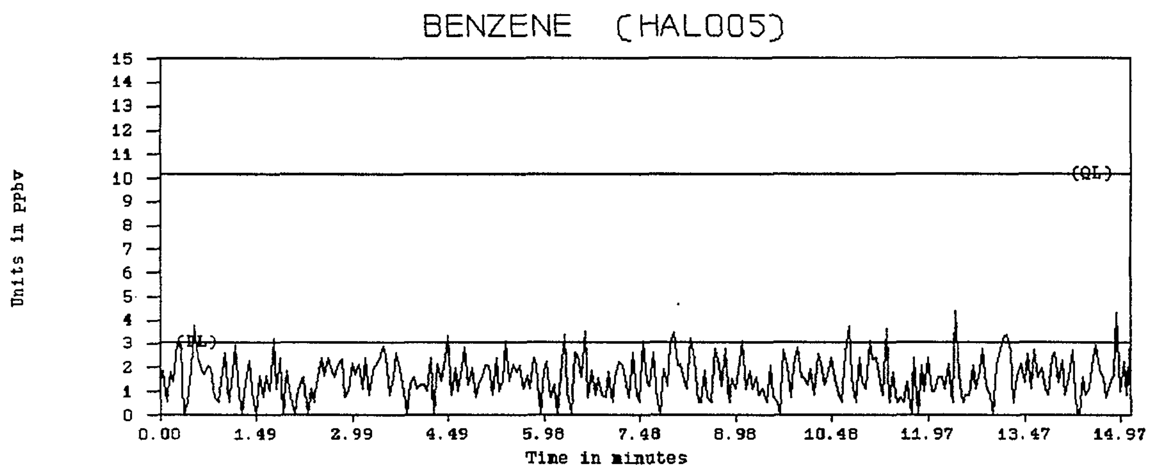
FIGURE 1a
Stationary Monitoring at Pit 1 for Vinyl Chloride, Benzene, and Ethylisothiocyanate
Halby Chemical Site, Wilmington, DE





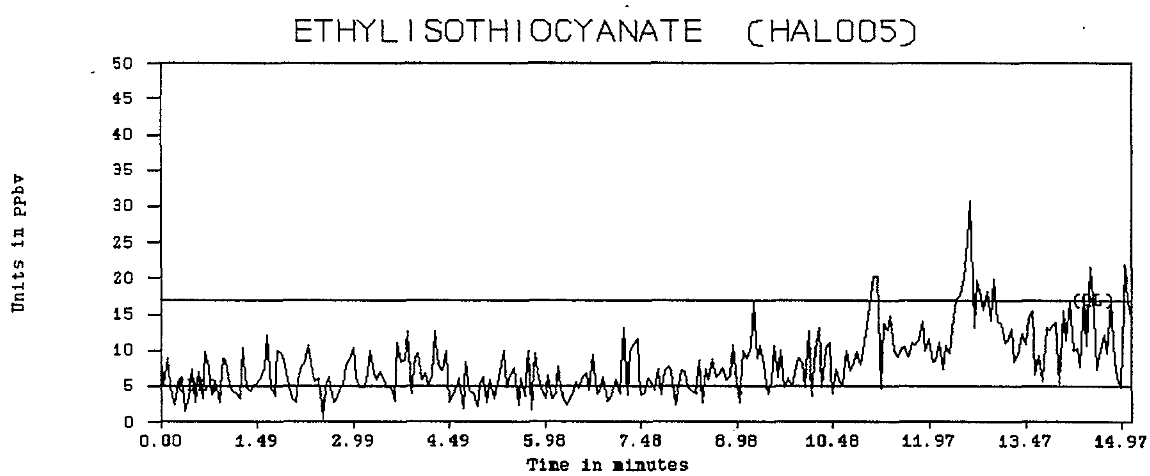


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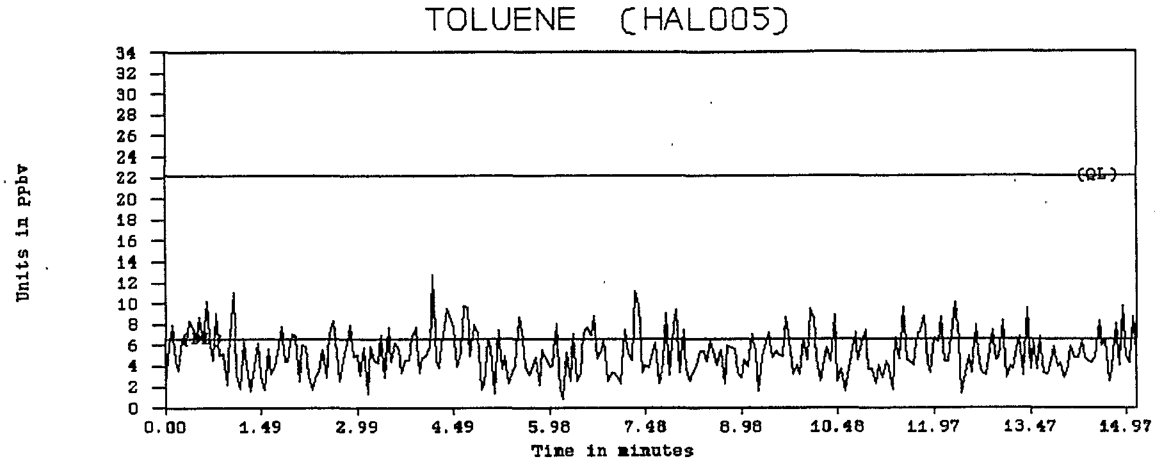
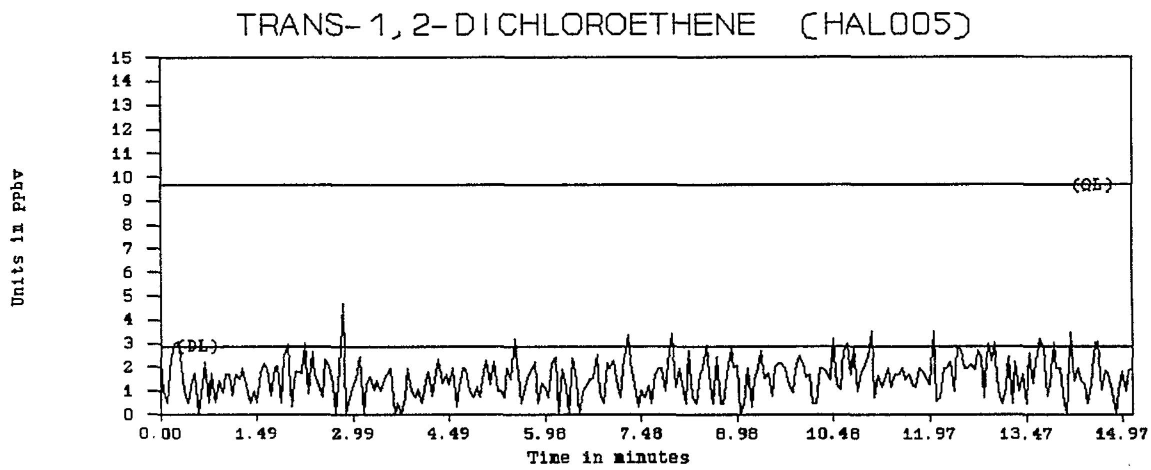
FIGURE 1b
Stationary Monitoring at Pit 1 for Toluene, Trans-1,2-Dichloroethene, and Xylene
Halby Chemical Site, Wilmington, DE





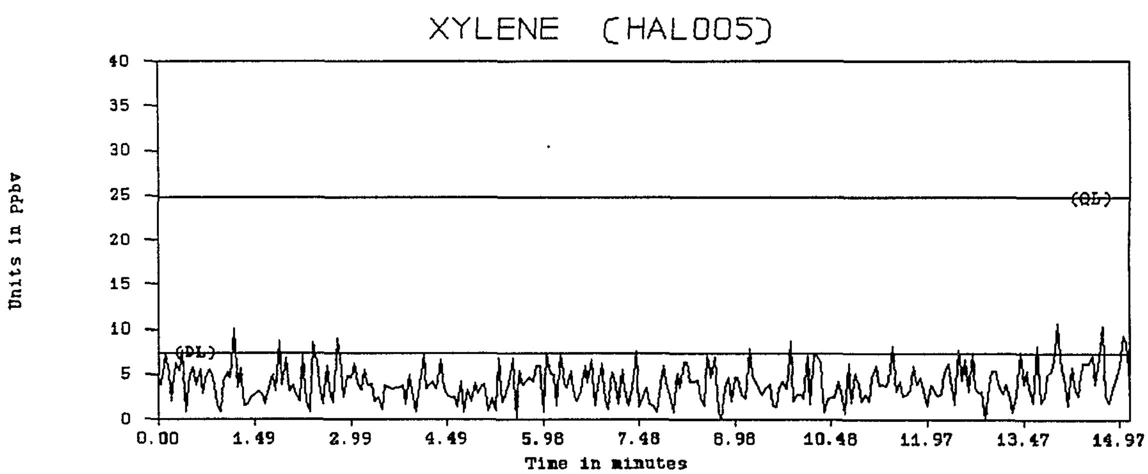


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FIGURE 1c
Stationary Monitoring at Pit 1 for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE

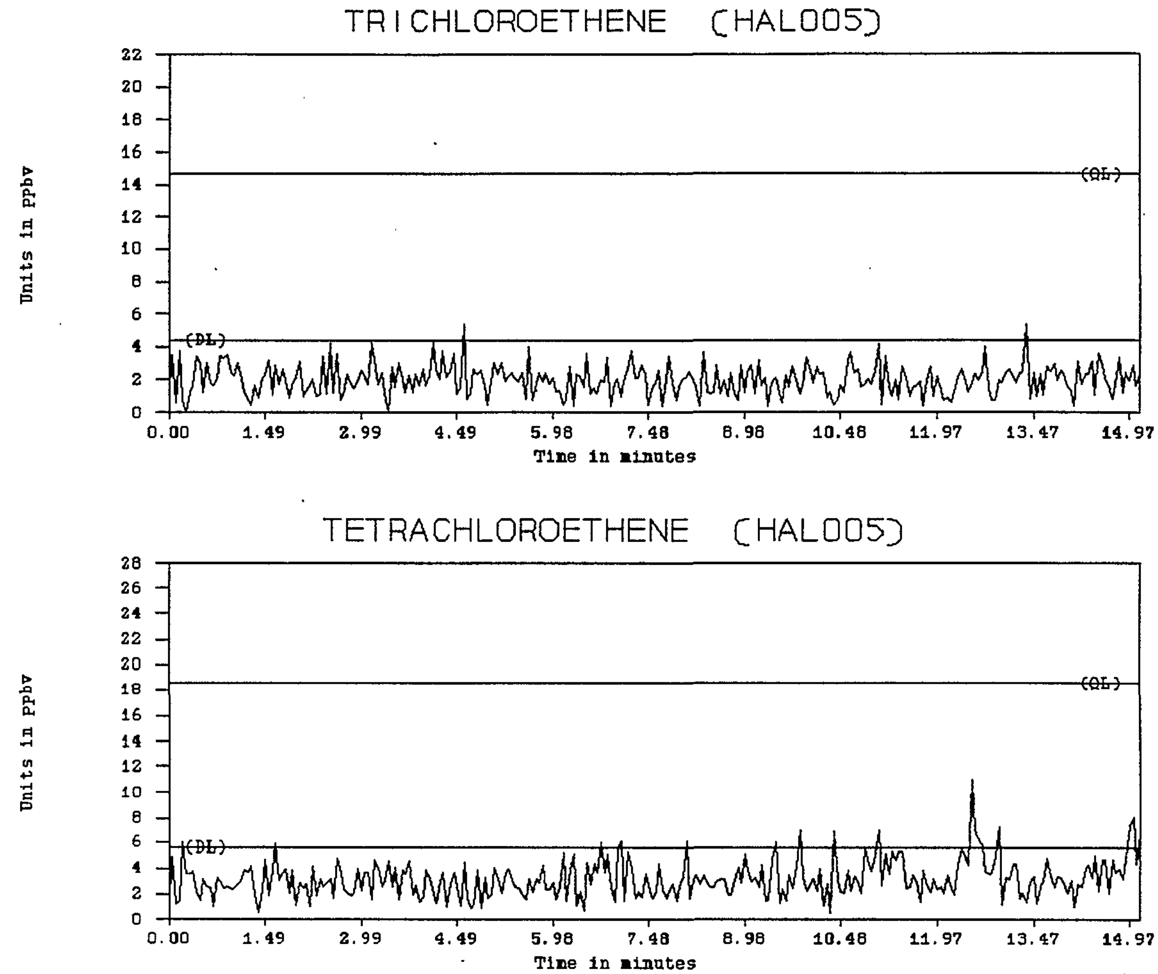

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FIGURE 1d
Background Subtracted Parent Ion Spectrum at Pit 1
Halby Chemical Site, Wilmington, DE

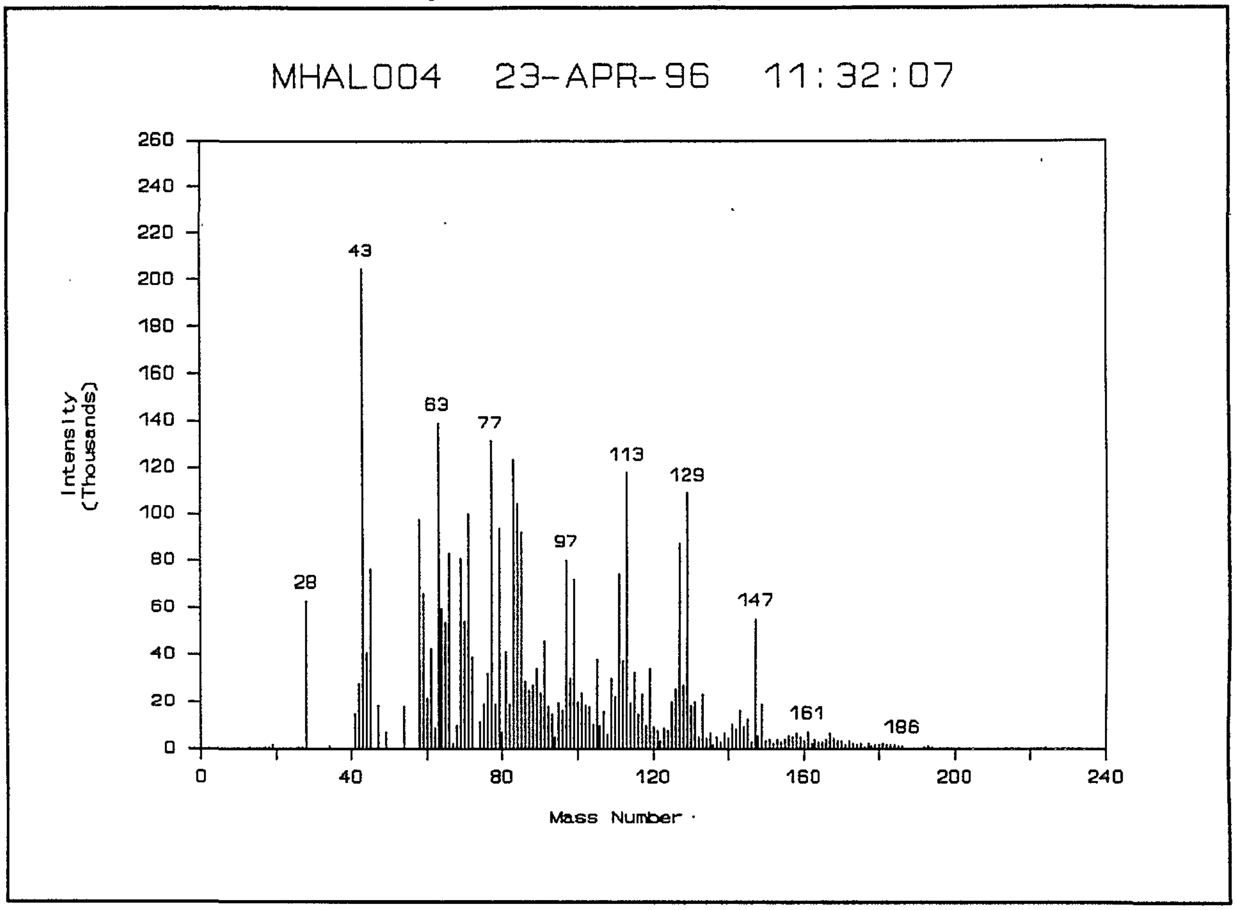

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FIGURE 1e
Background Subtracted Parent Ion Spectrum at Pit 1
Halby Chemical Site, Wilmington, DE

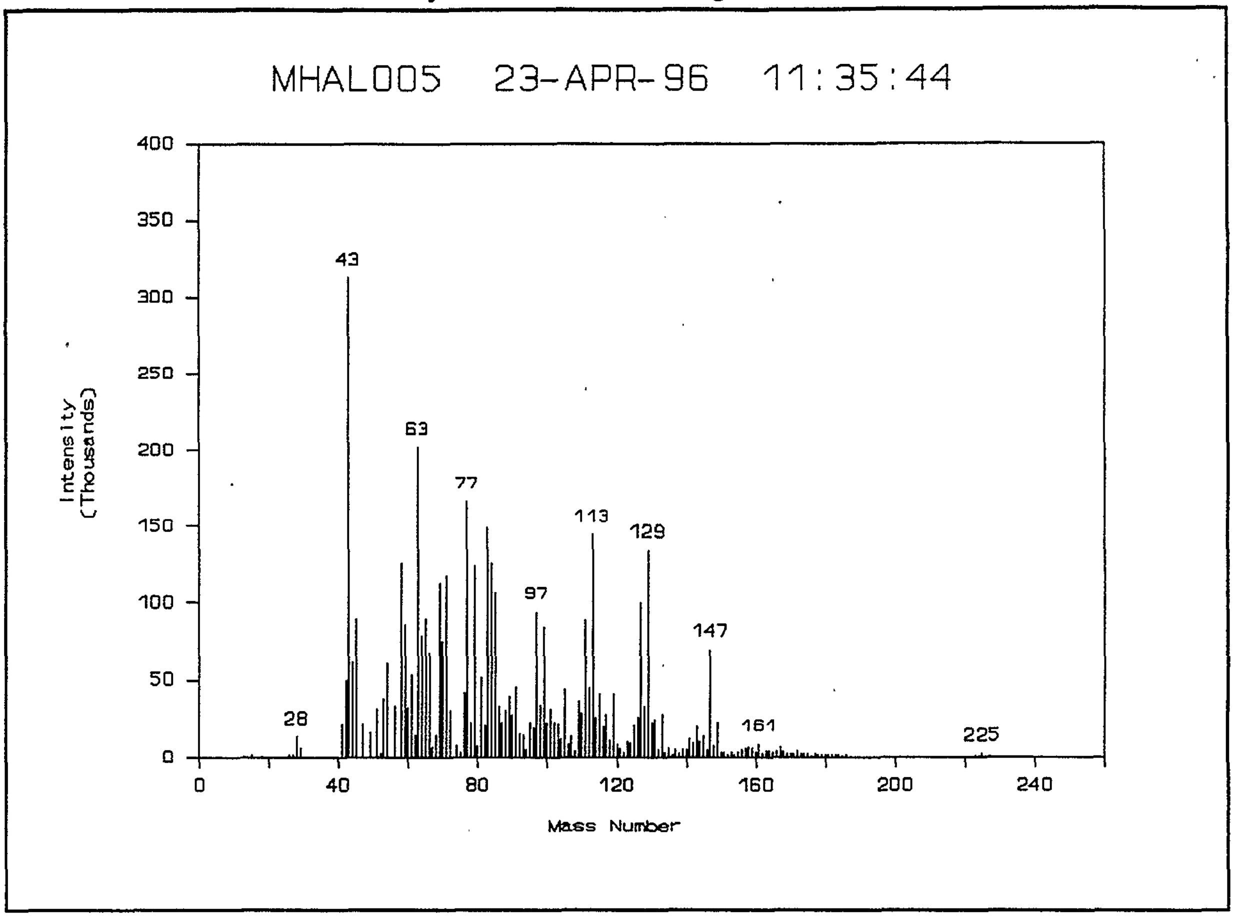

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FIGURE 1f
Daughter Ion Spectrum (m/z = 63) at Pit 1
Halby Chemical Site, Wilmington, DE

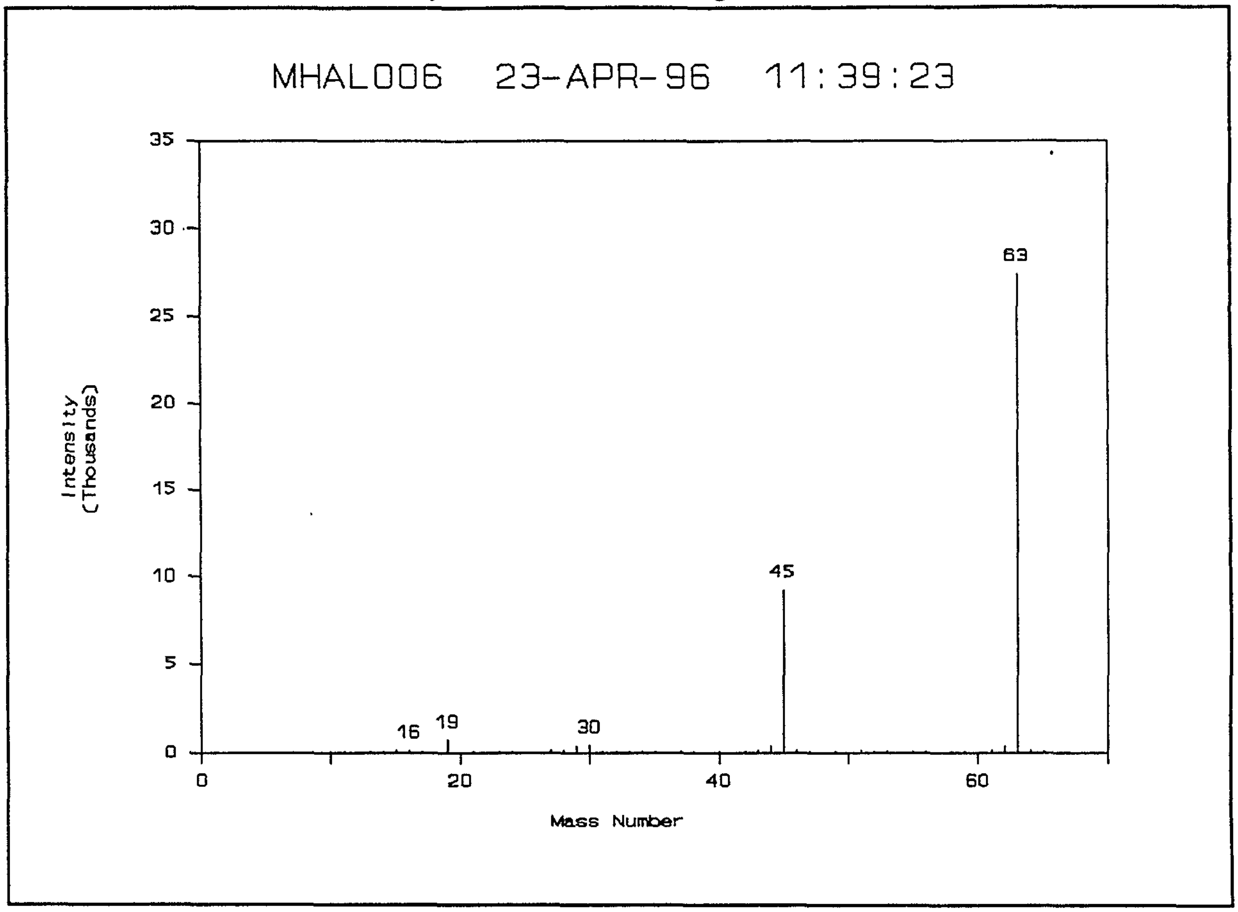

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FIGURE 1g
Daughter Ion Spectrum (m/z = 77) at Pit 1
Halby Chemical Site, Wilmington, DE

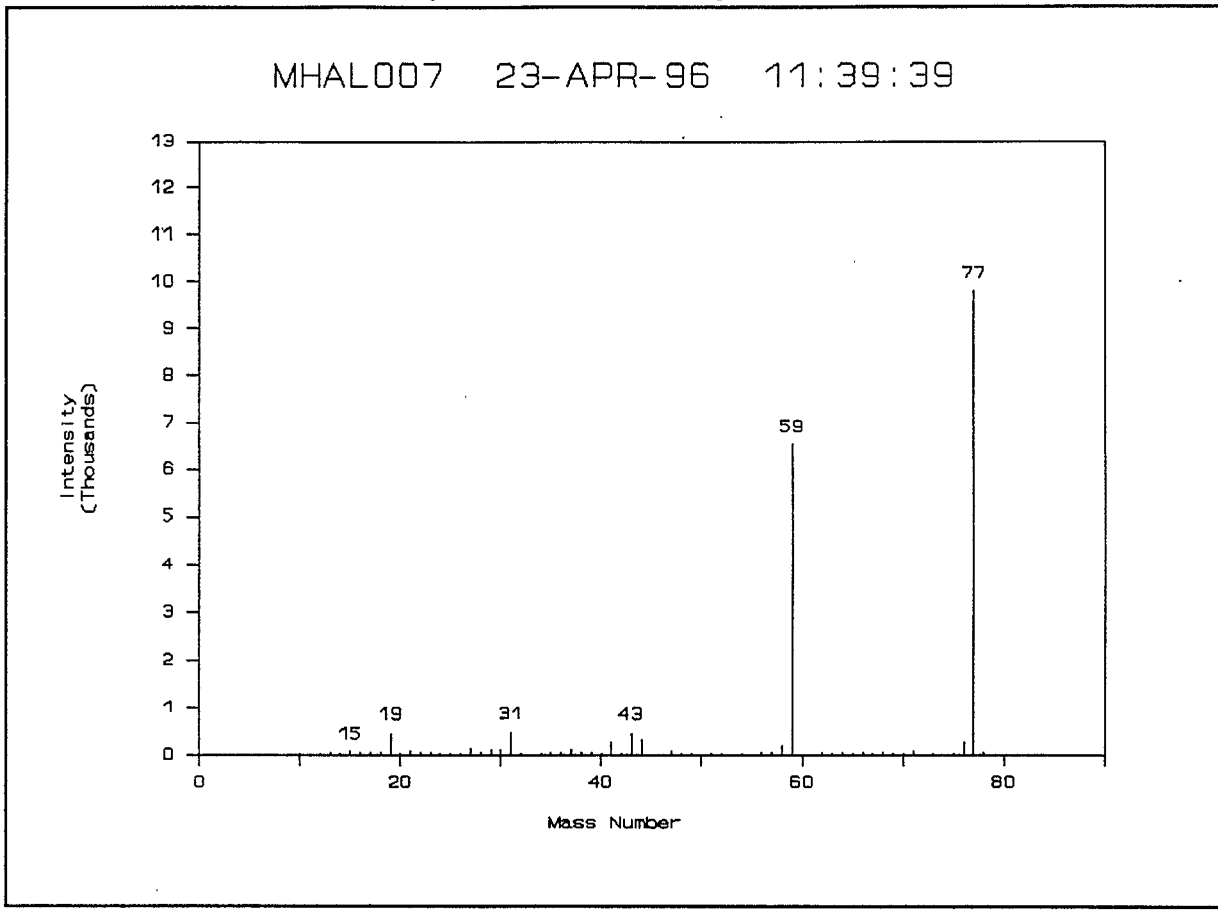

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FIGURE 1h
Daughter Ion Spectrum (m/z = 83) at Pit 1
Halby Chemical Site, Wilmington, DE

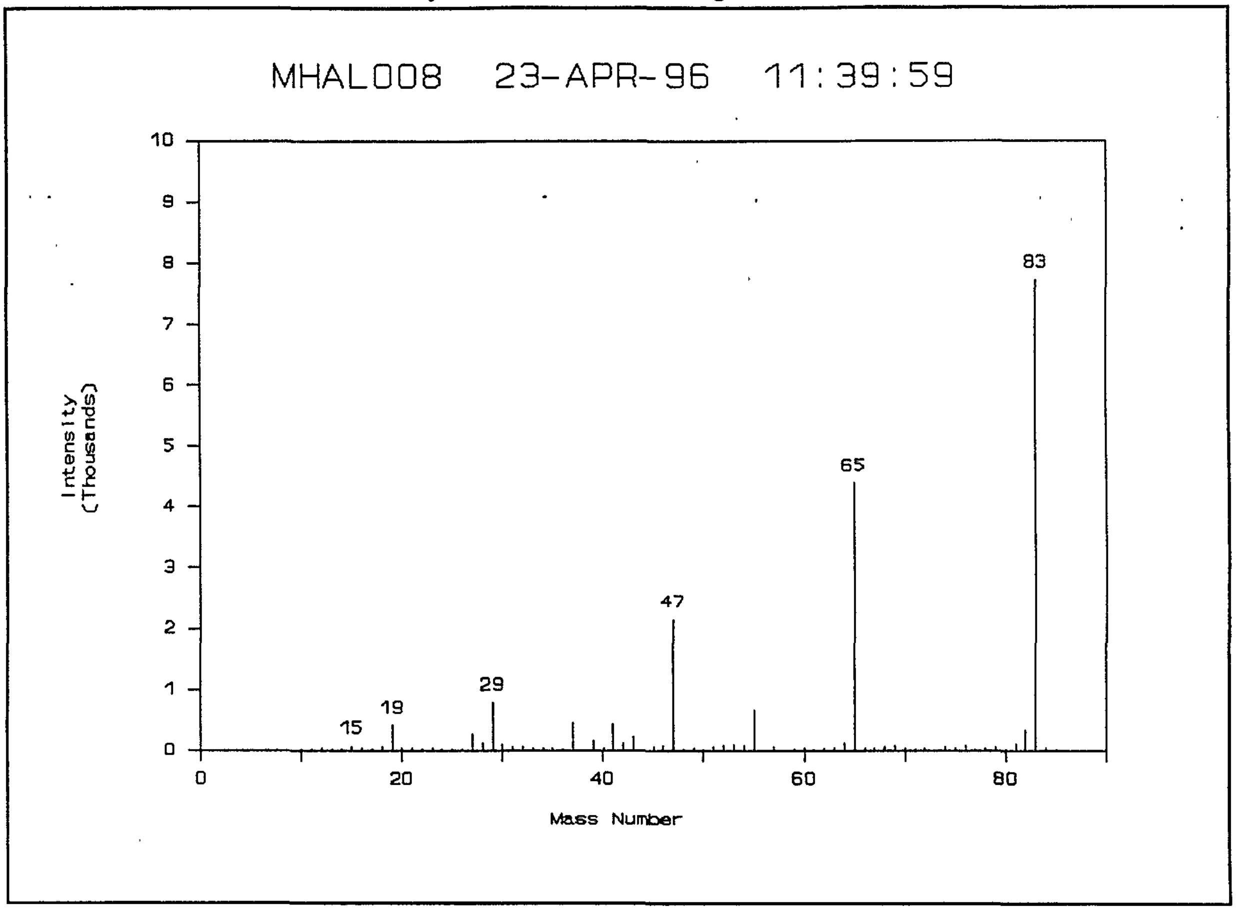

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FIGURE 1i
Daughter Ion Spectrum (m/z = 97) at Pit 1
Halby Chemical Site, Wilmington, DE

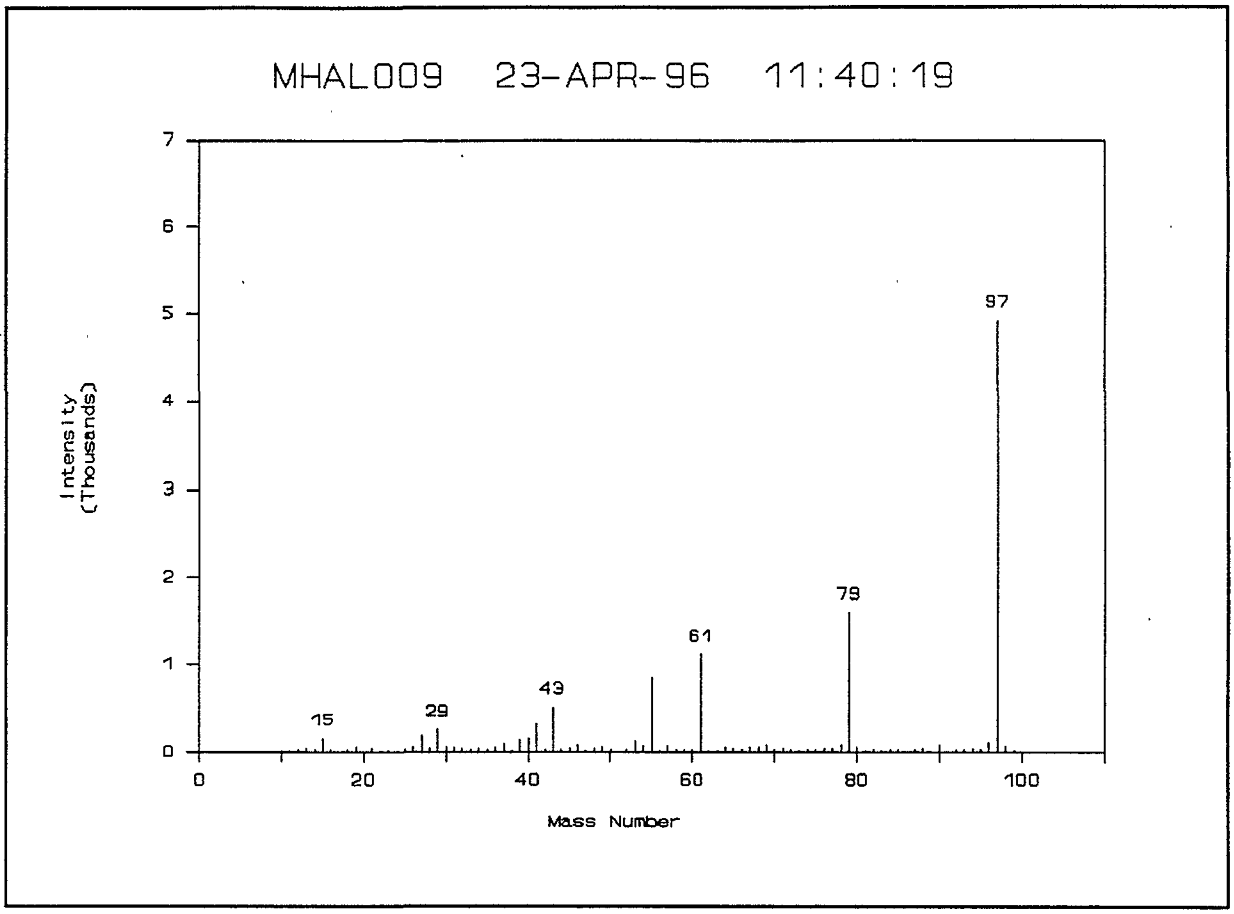

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FIGURE 1j
Daughter Ion Spectrum (m/z = 113) at Pit 1
Halby Chemical Site, Wilmington, DE

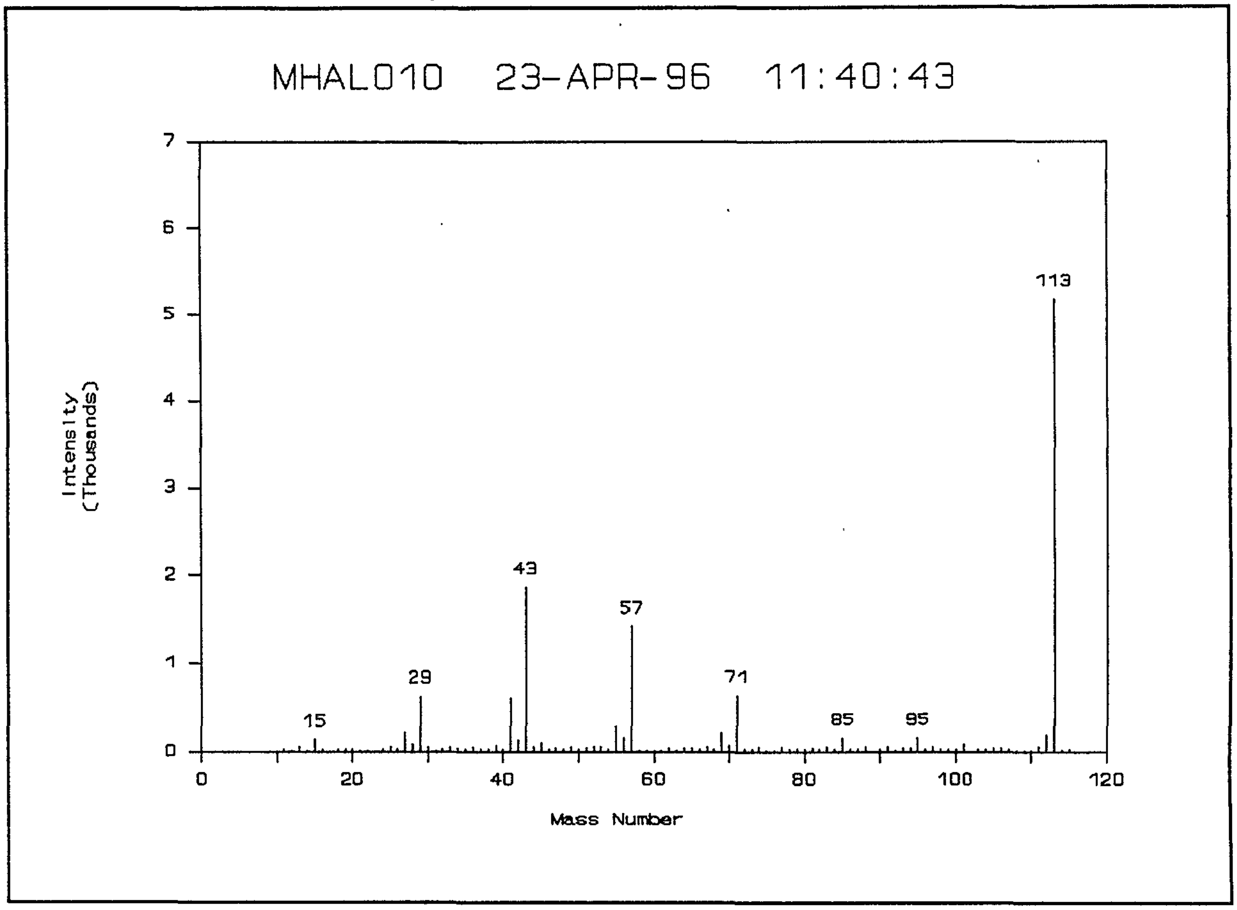

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FIGURE 1k
Daughter Ion Spectrum (m/z = 129) at Pit 1
Halby Chemical Site, Wilmington, DE

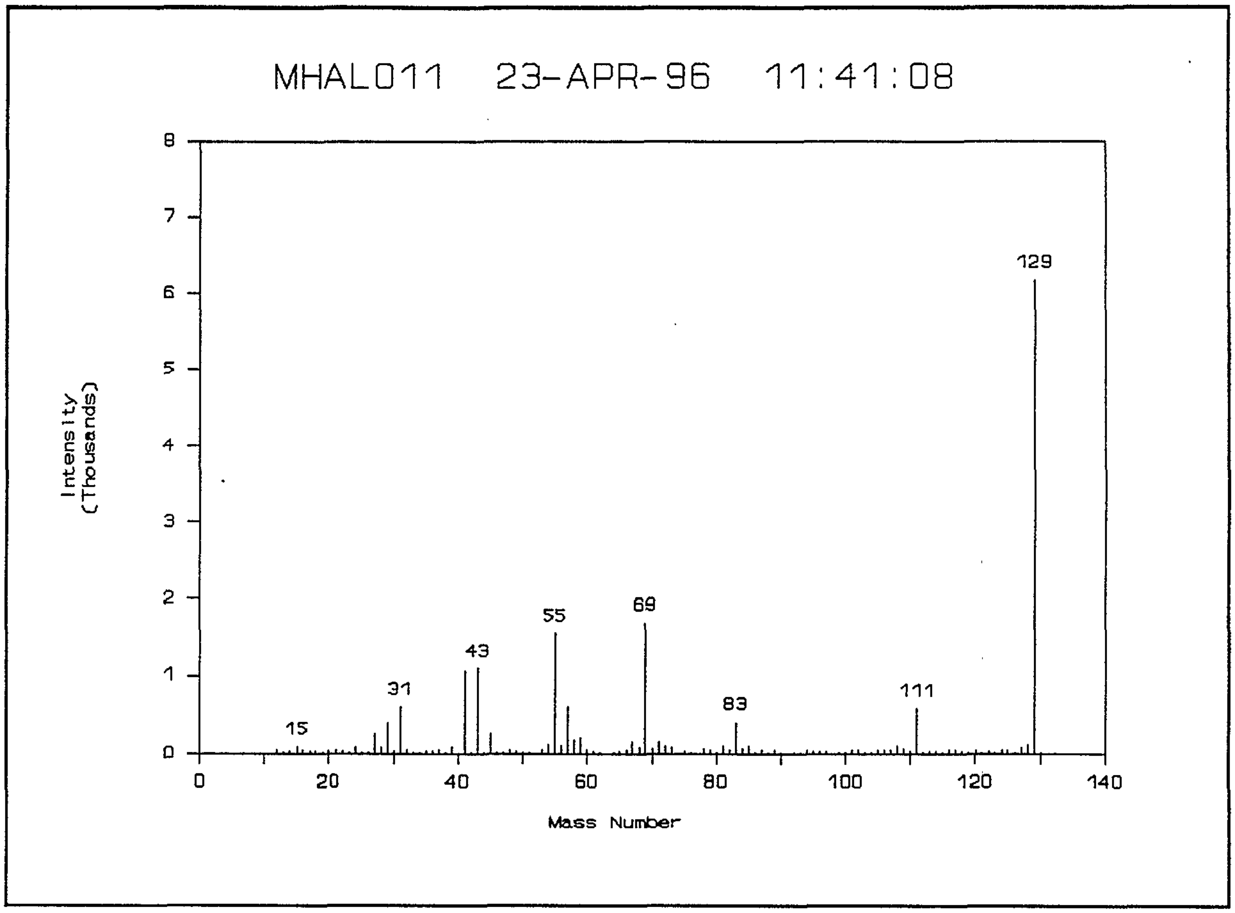

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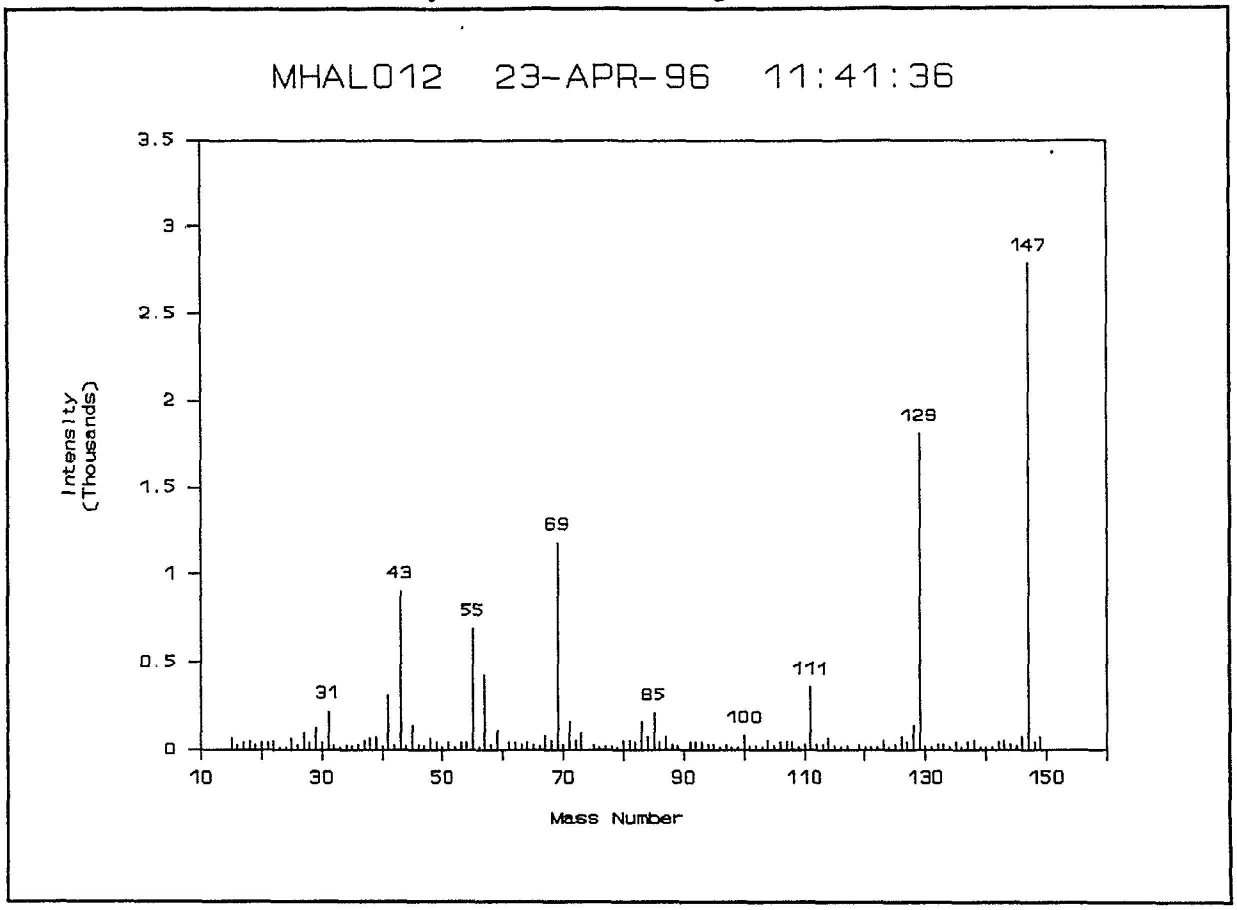
FIGURE 11
Daughter Ion Spectrum (m/z = 147) at Pit 1
Halby Chemical Site, Wilmington, DE



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Pit 2

FIGURE 2a
Stationary Monitoring at Pit 2 for Vinyl Chloride, Benzene, and Ethylisothiocyanate
Halby Chemical Site, Wilmington, DE

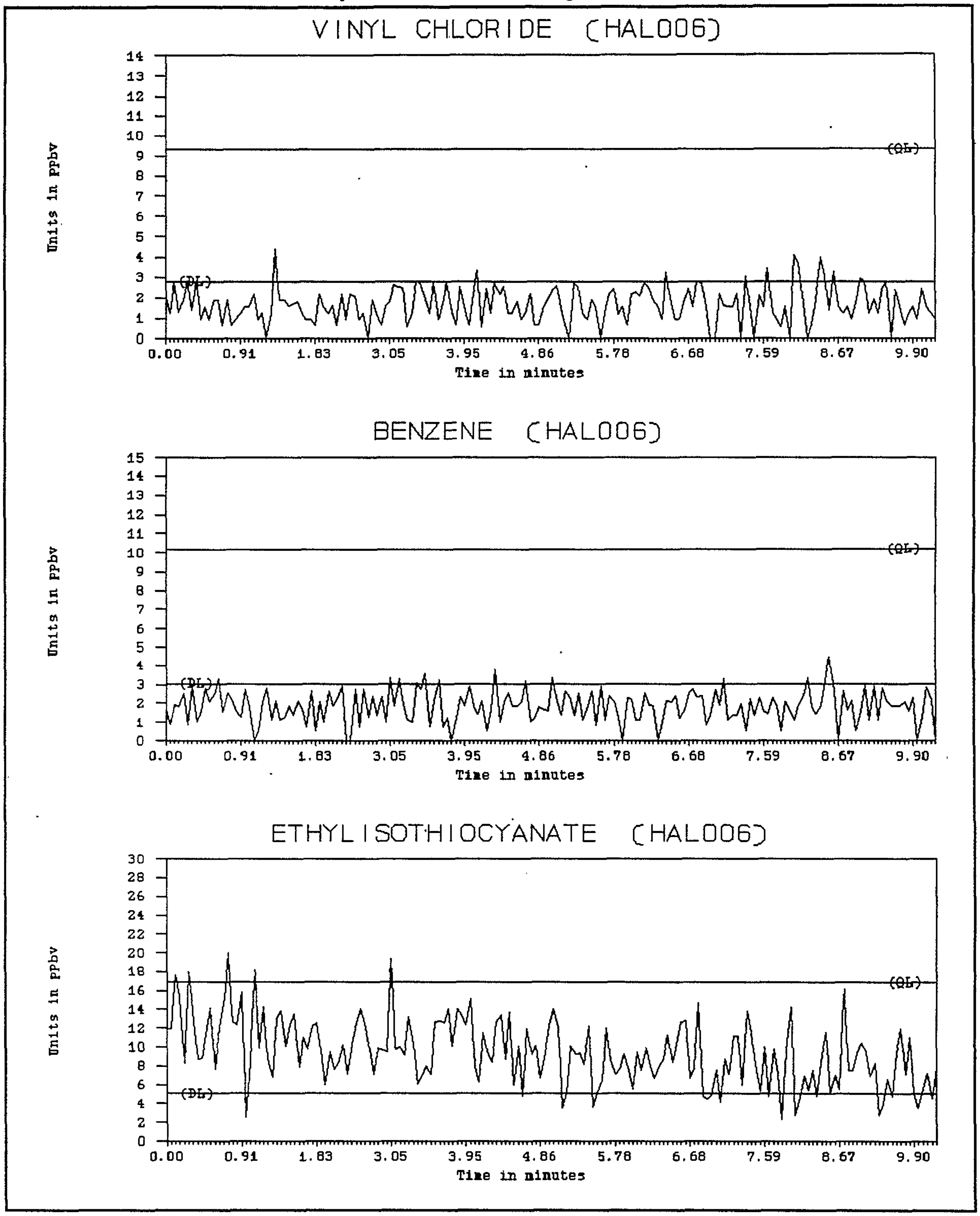

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FIGURE 2b
Stationary Monitoring at Pit 2 for Toluene, Trans-1,2-Dichloroethene, and Xylene
Halby Chemical Site, Wilmington, DE

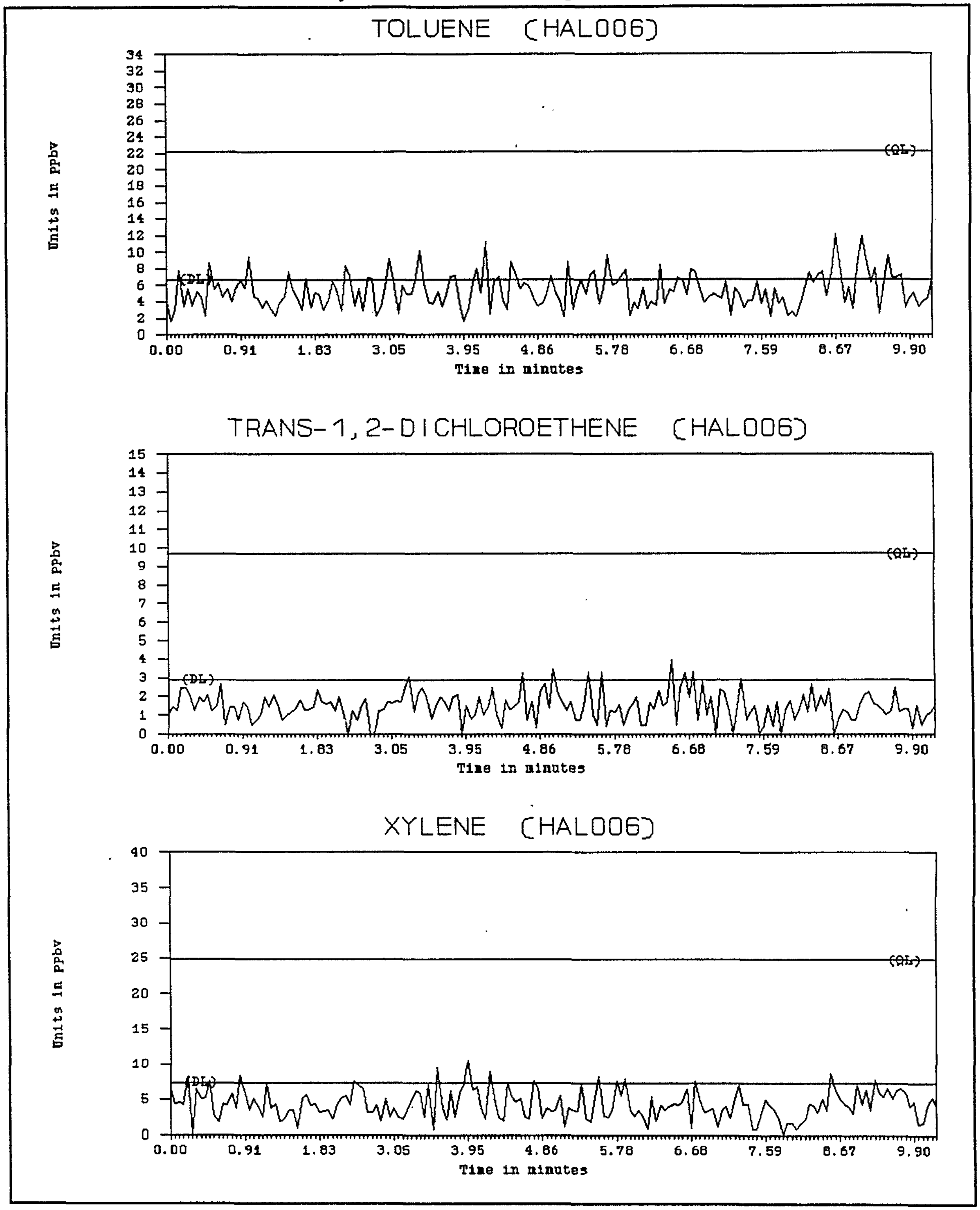

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FIGURE 2c
Stationary Monitoring at Pit 2 for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE

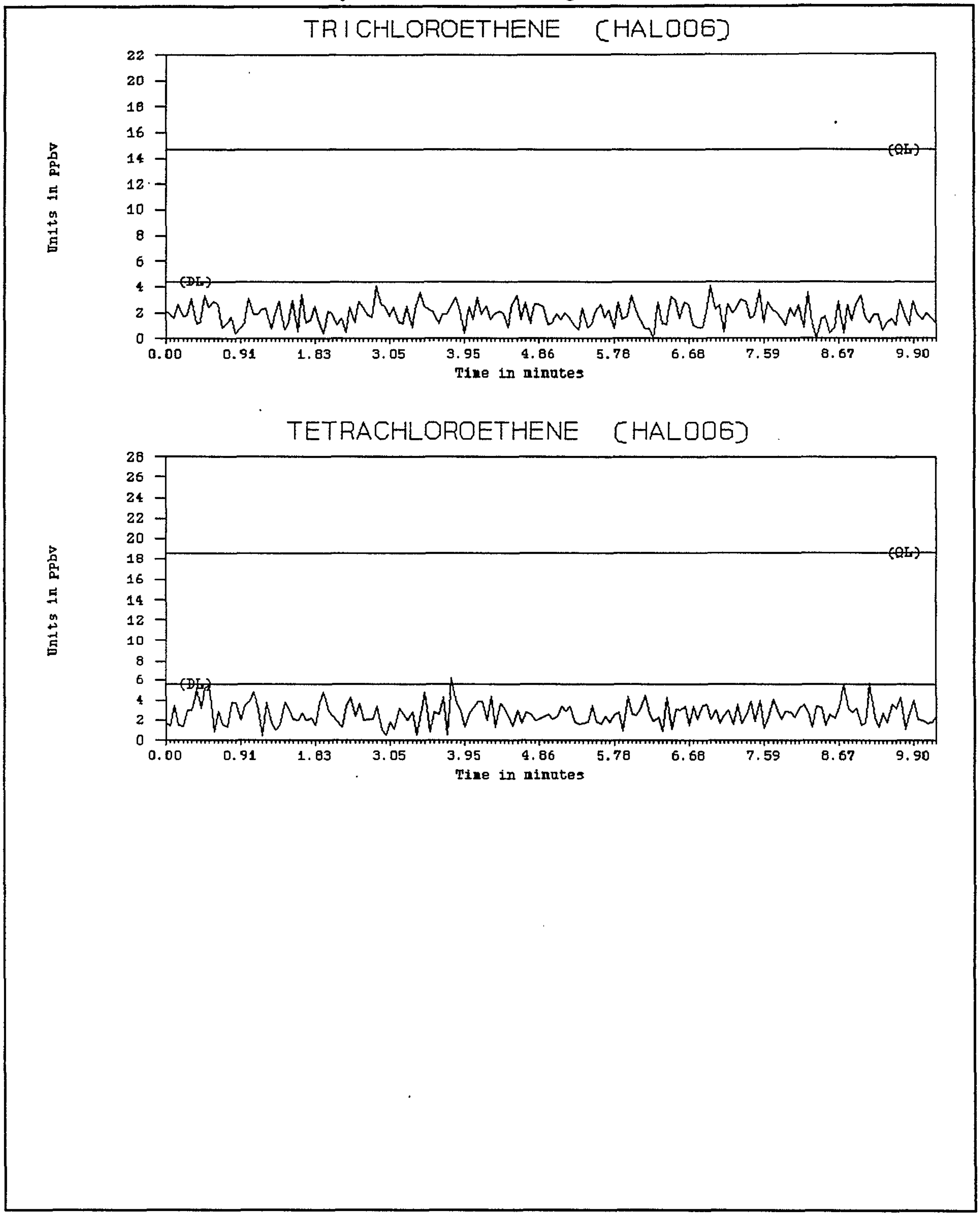

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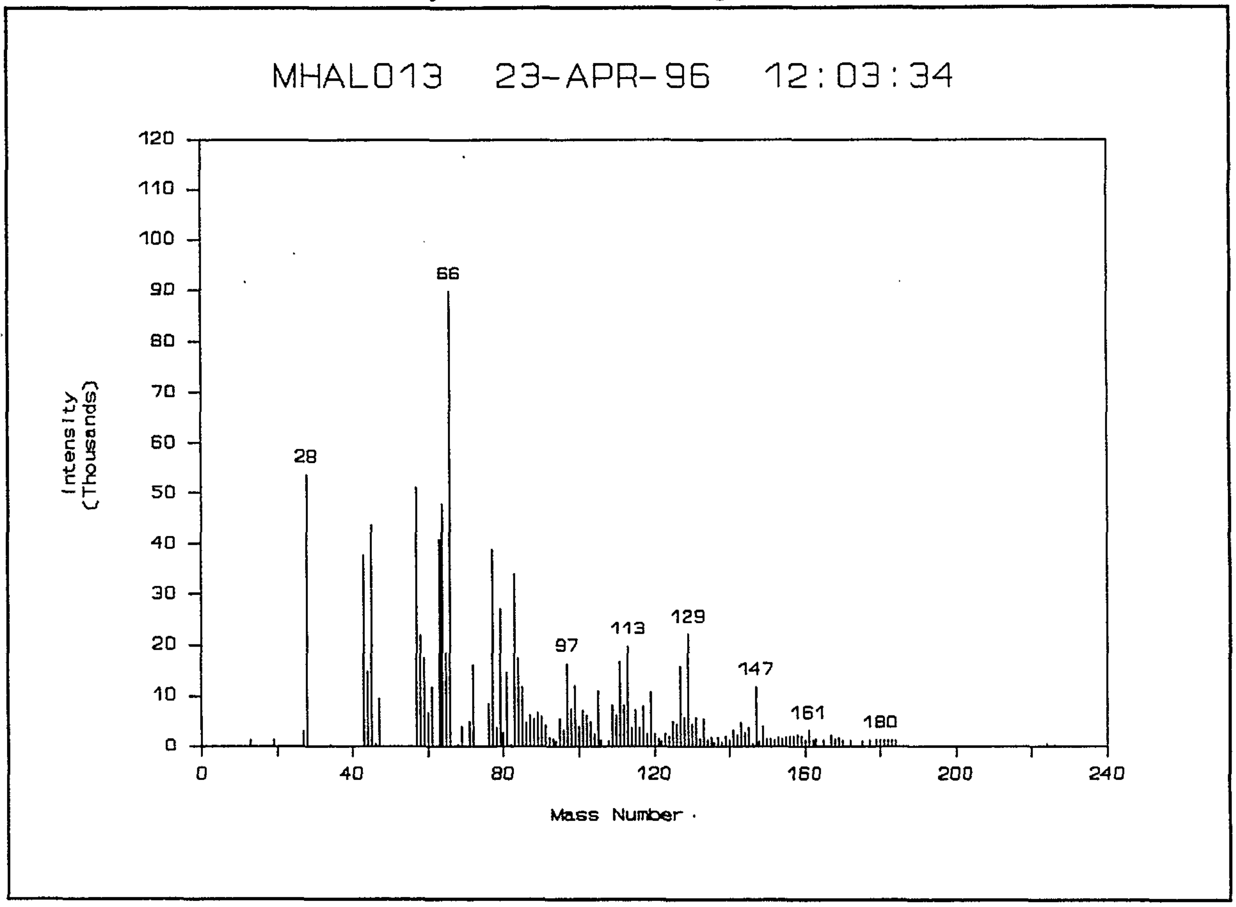
FIGURE 2d
Background Subtracted Parent Ion Spectrum at Pit 2
Halby Chemical Site, Wilmington, DE



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Pit 3

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FIGURE 3a
Stationary Monitoring at Pit 3 for Vinyl Chloride, Benzene, and Ethylisothiocyanate
Halby Chemical Site, Wilmington, DE

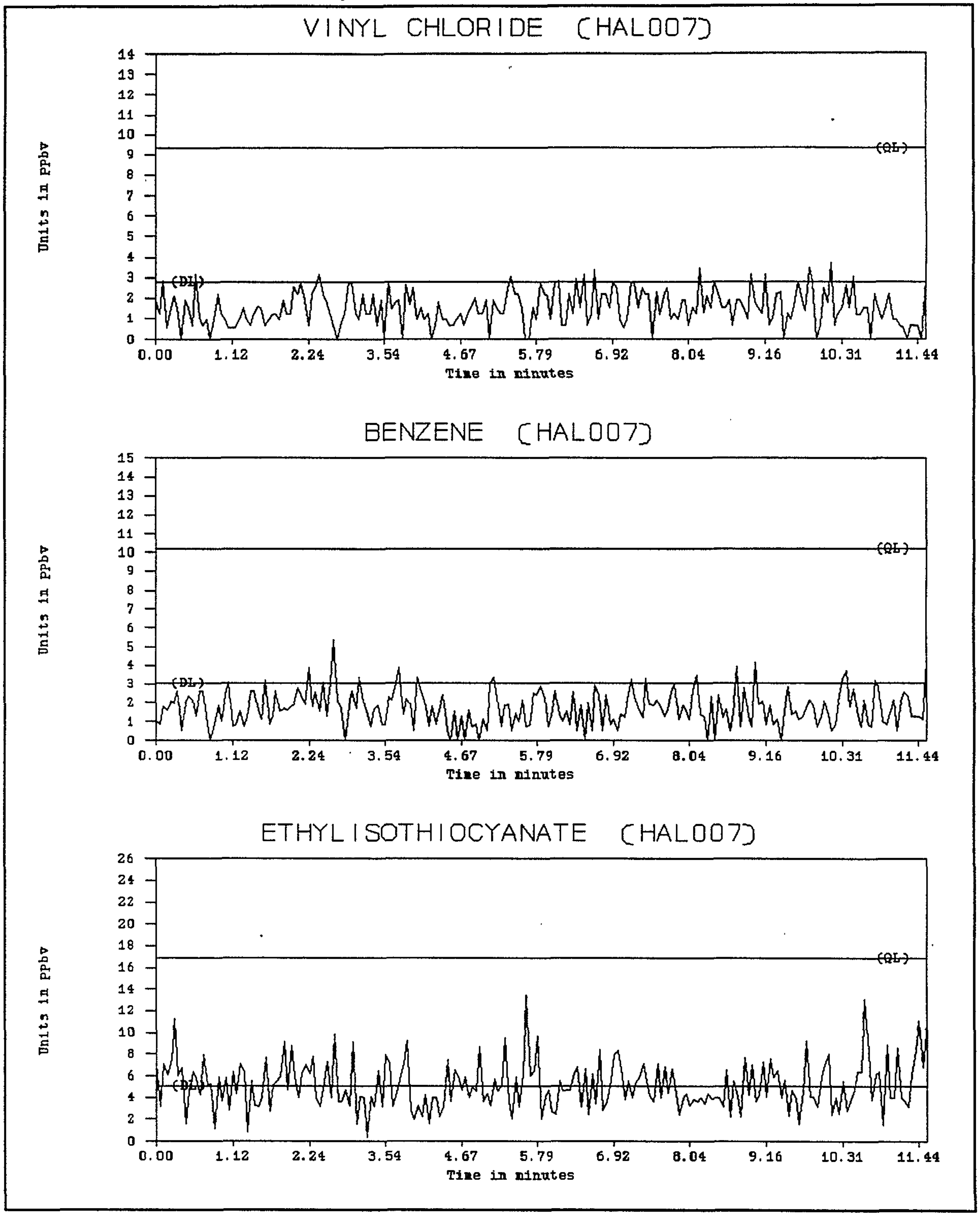

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FIGURE 3b

Stationary Monitoring at Pit 3 for Toluene, Trans-1,2-Dichloroethene, and Xylene

Halby Chemical Site, Wilmington, DE

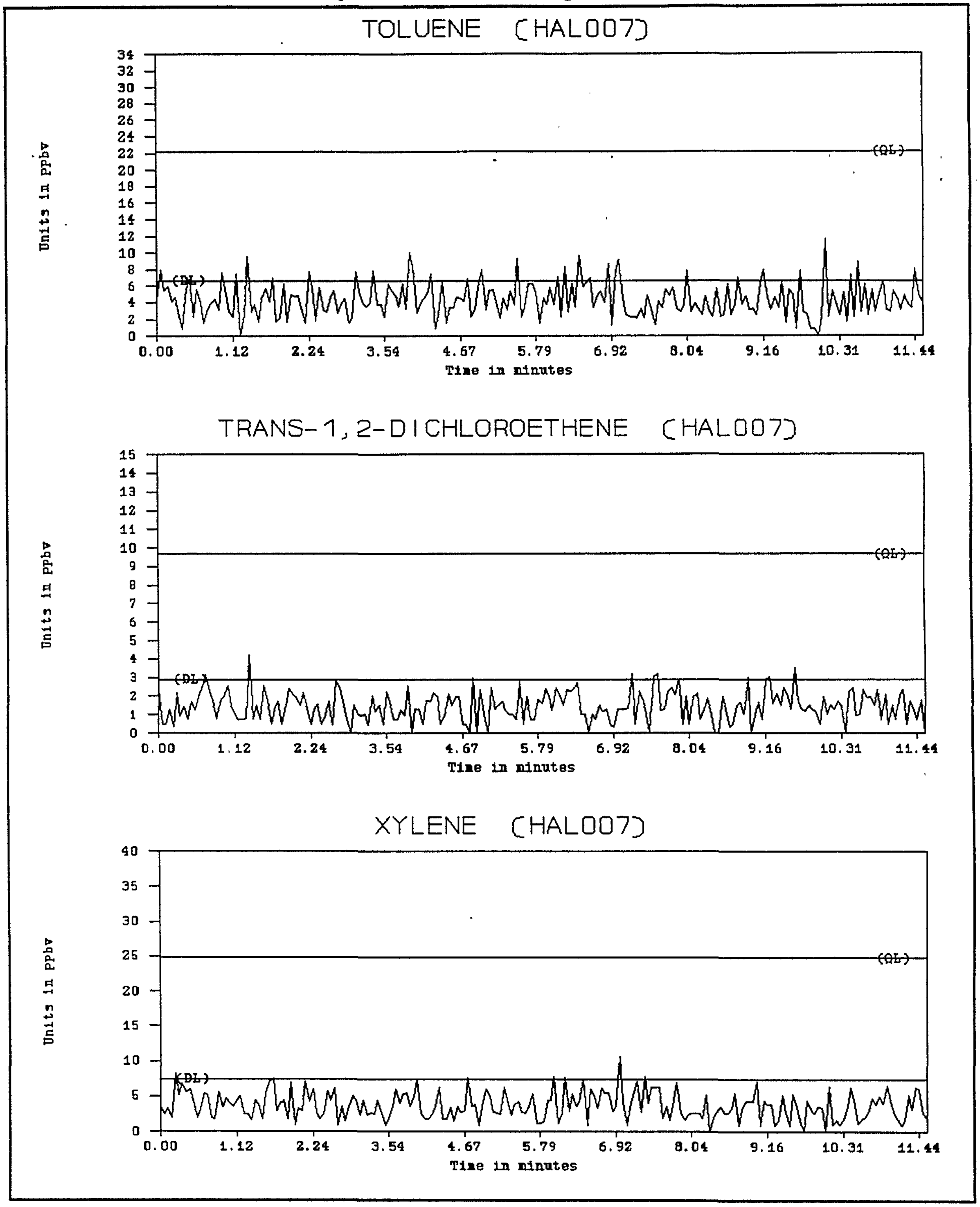

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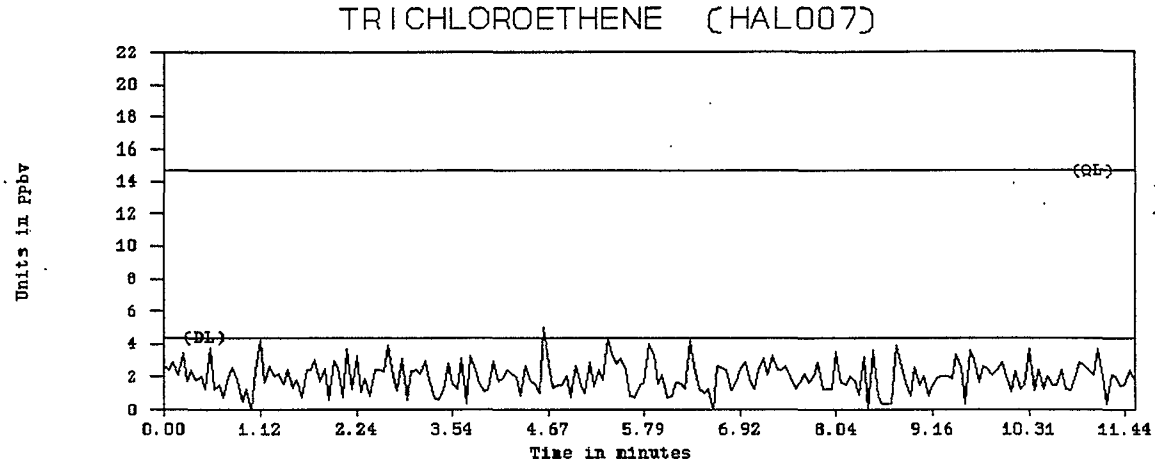
FIGURE 3c
Stationary Monitoring at Pit 3 for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE



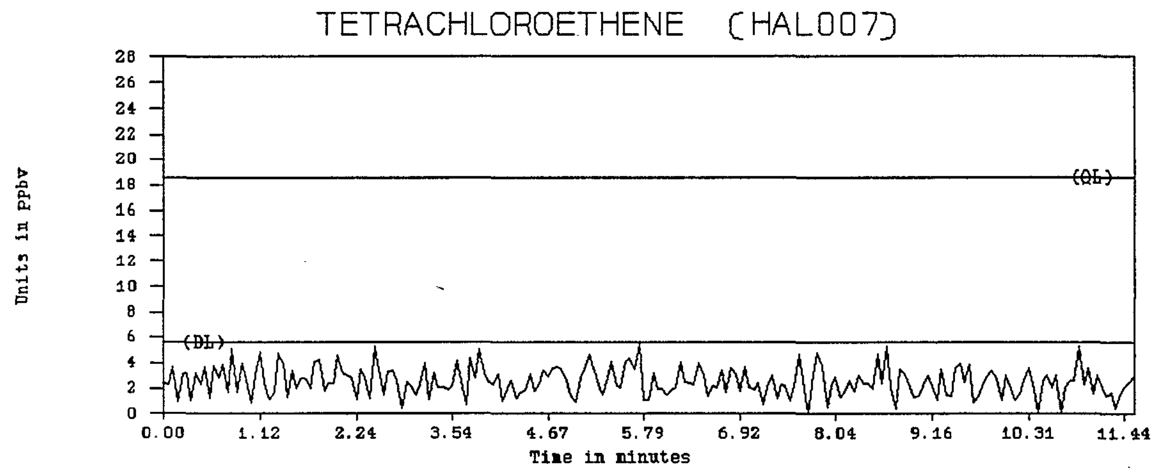


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FIGURE 3d
Background Subtracted Parent Ion Spectrum at Pit 3
Halby Chemical Site, Wilmington, DE

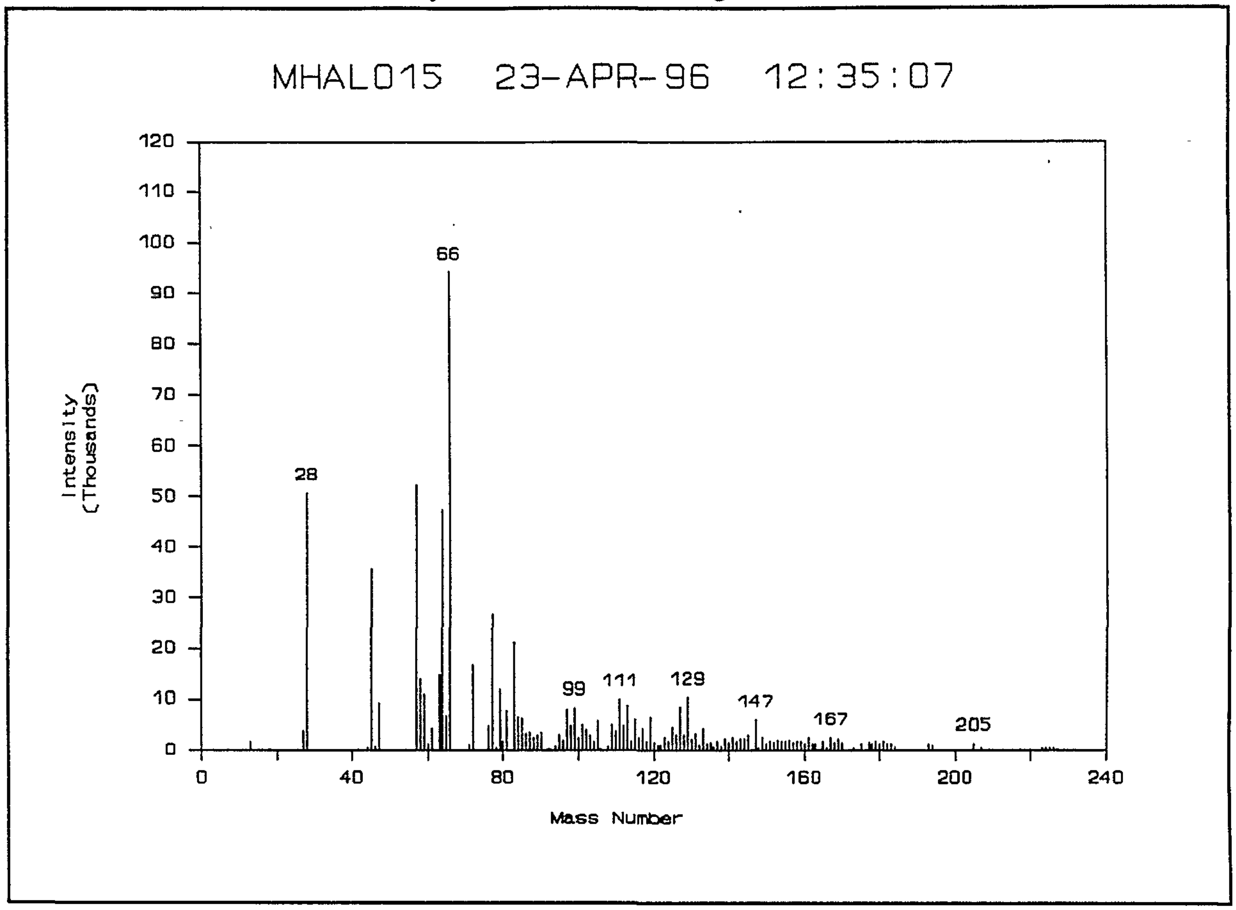

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FIGURE 3e
Daughter Ion Spectrum (m/z = 66) at Pit 3
Halby Chemical Site, Wilmington, DE

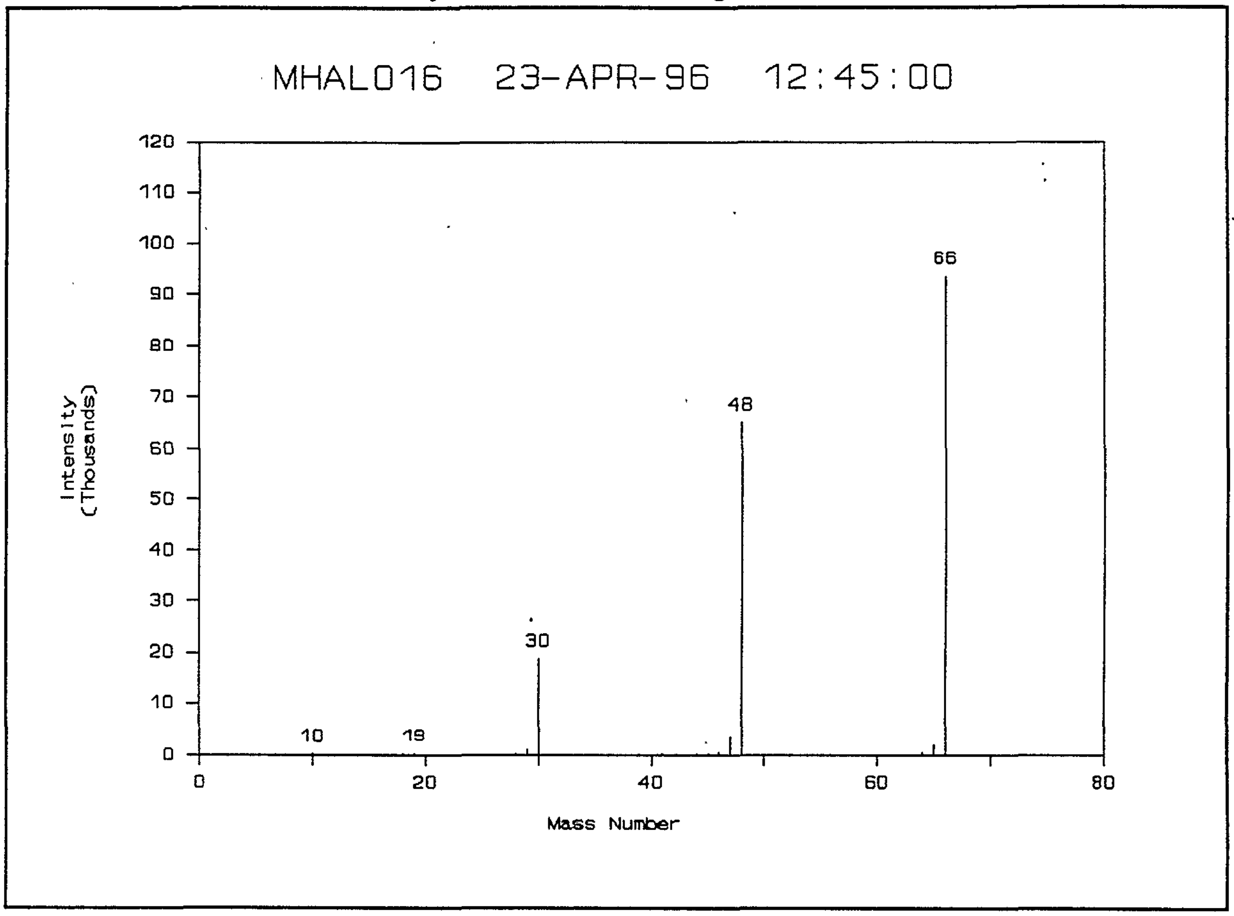

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FIGURE 3f
Daughter Ion Spectrum (m/z = 77) at Pit 3
Halby Chemical Site, Wilmington, DE

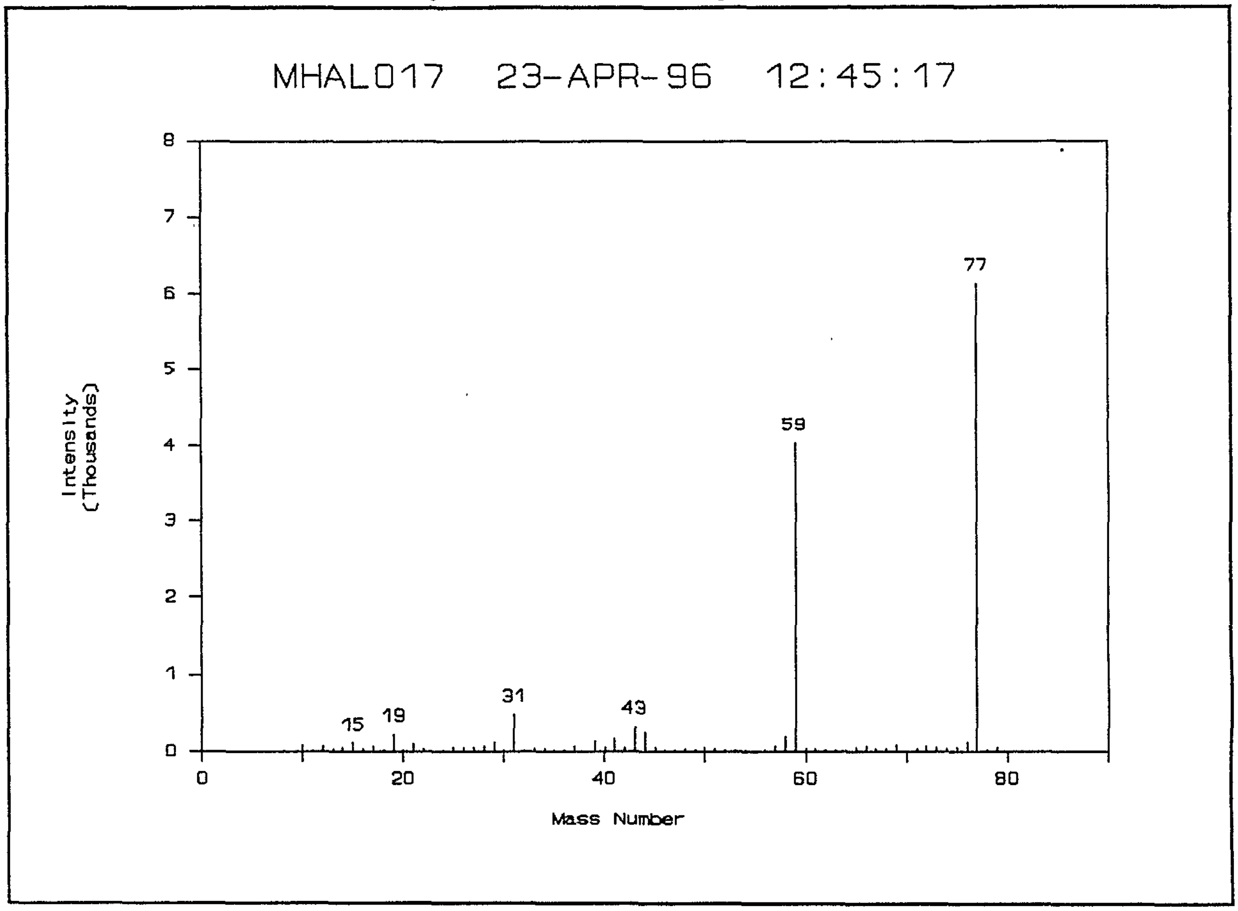

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FIGURE 3g
Daughter Ion Spectrum (m/z = 83) at Pit 3
Halby Chemical Site, Wilmington, DE

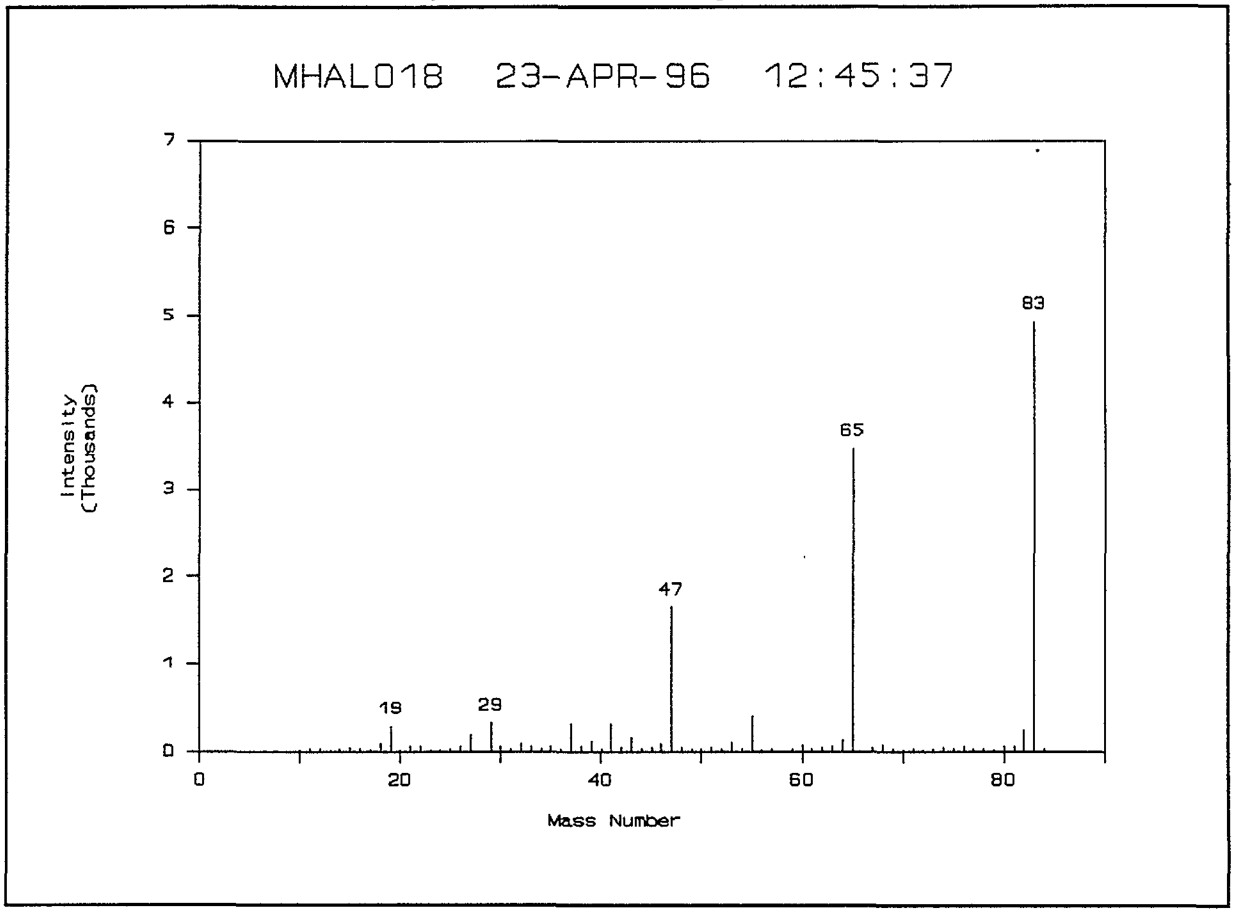

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FIGURE 3h
Daughter Ion Spectrum (m/z = 99) at Pit 3
Halby Chemical Site, Wilmington, DE

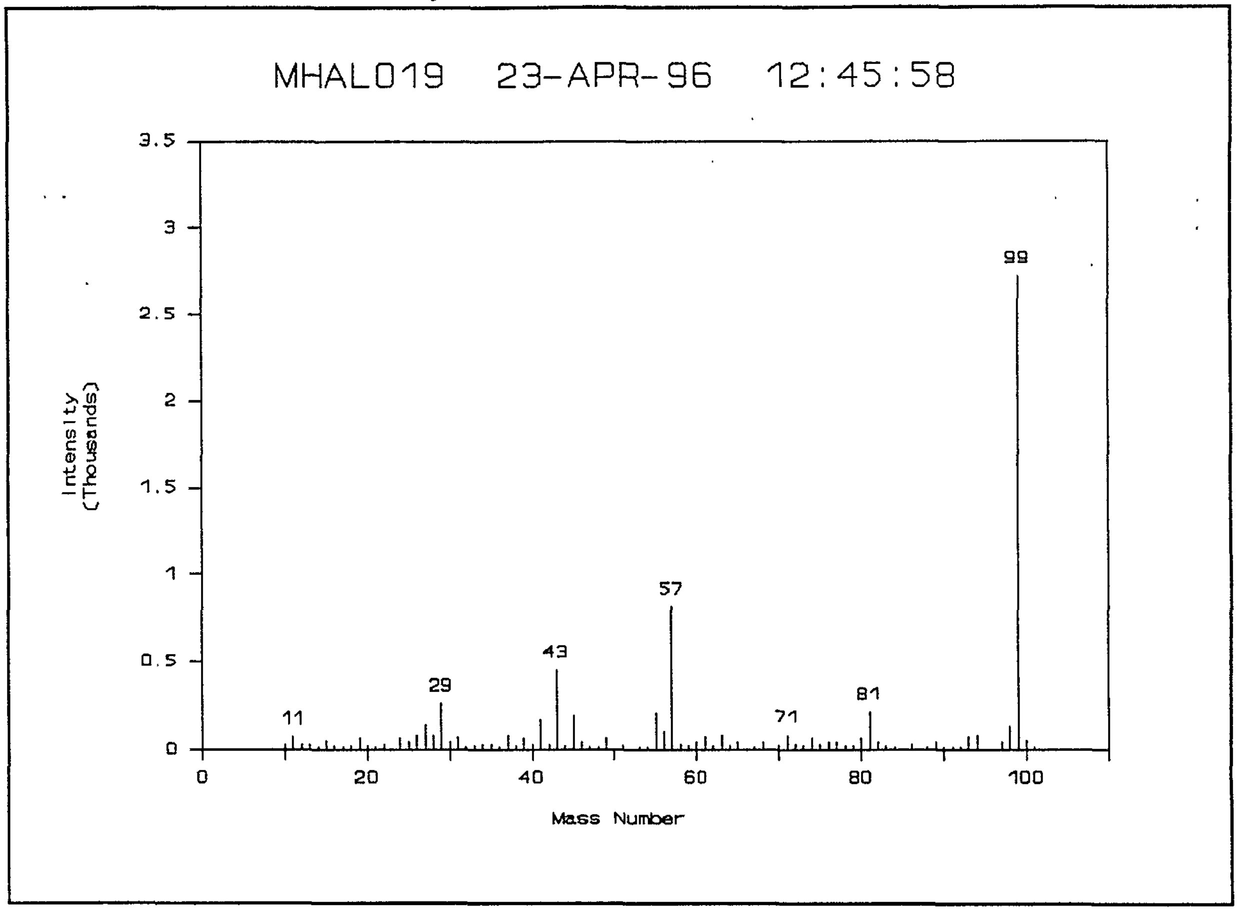

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FIGURE 3i
Daughter Ion Spectrum (m/z = 113) at Pit 3
Halby Chemical Site, Wilmington, DE

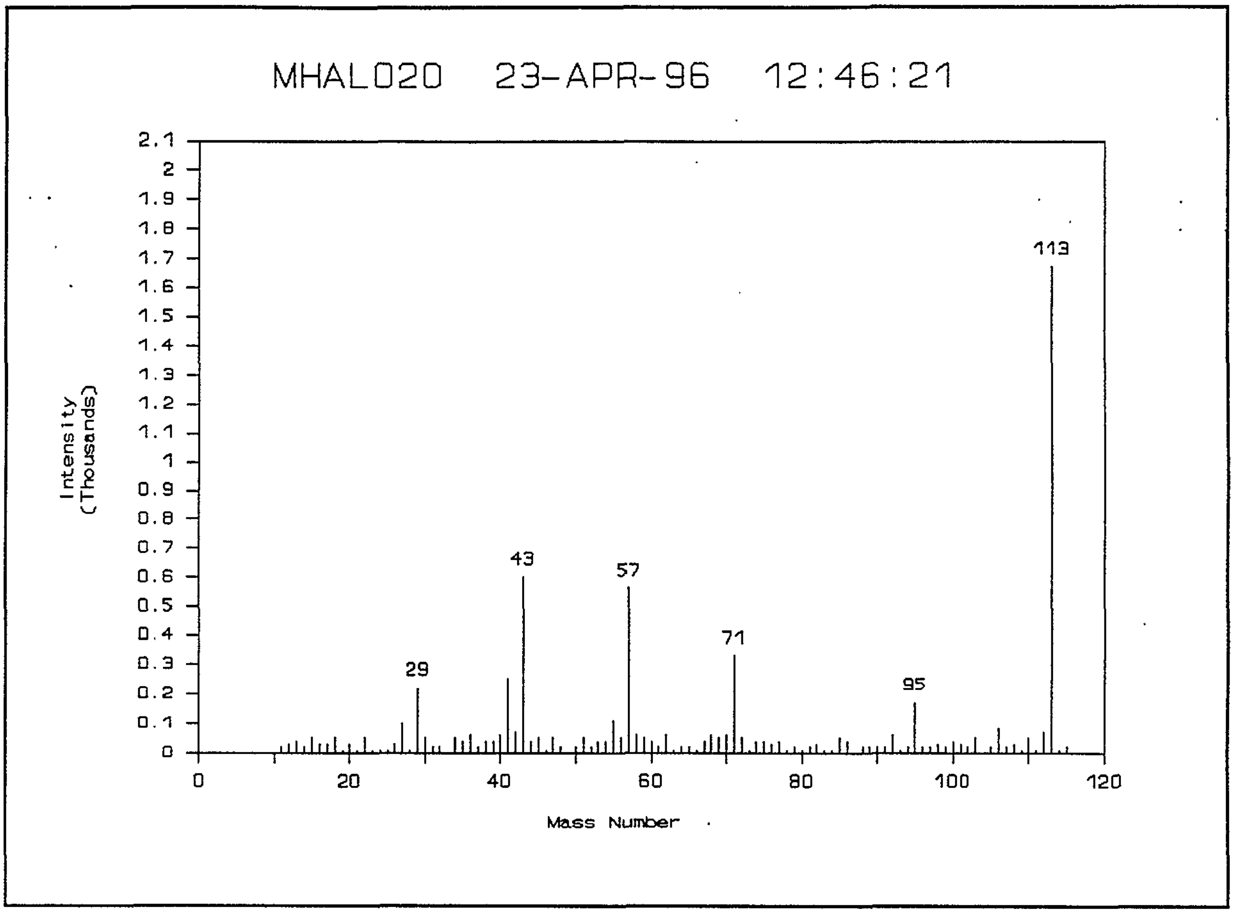

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FIGURE 3j
Daughter Ion Spectrum (m/z = 129) at Pit 3
Halby Chemical Site, Wilmington, DE

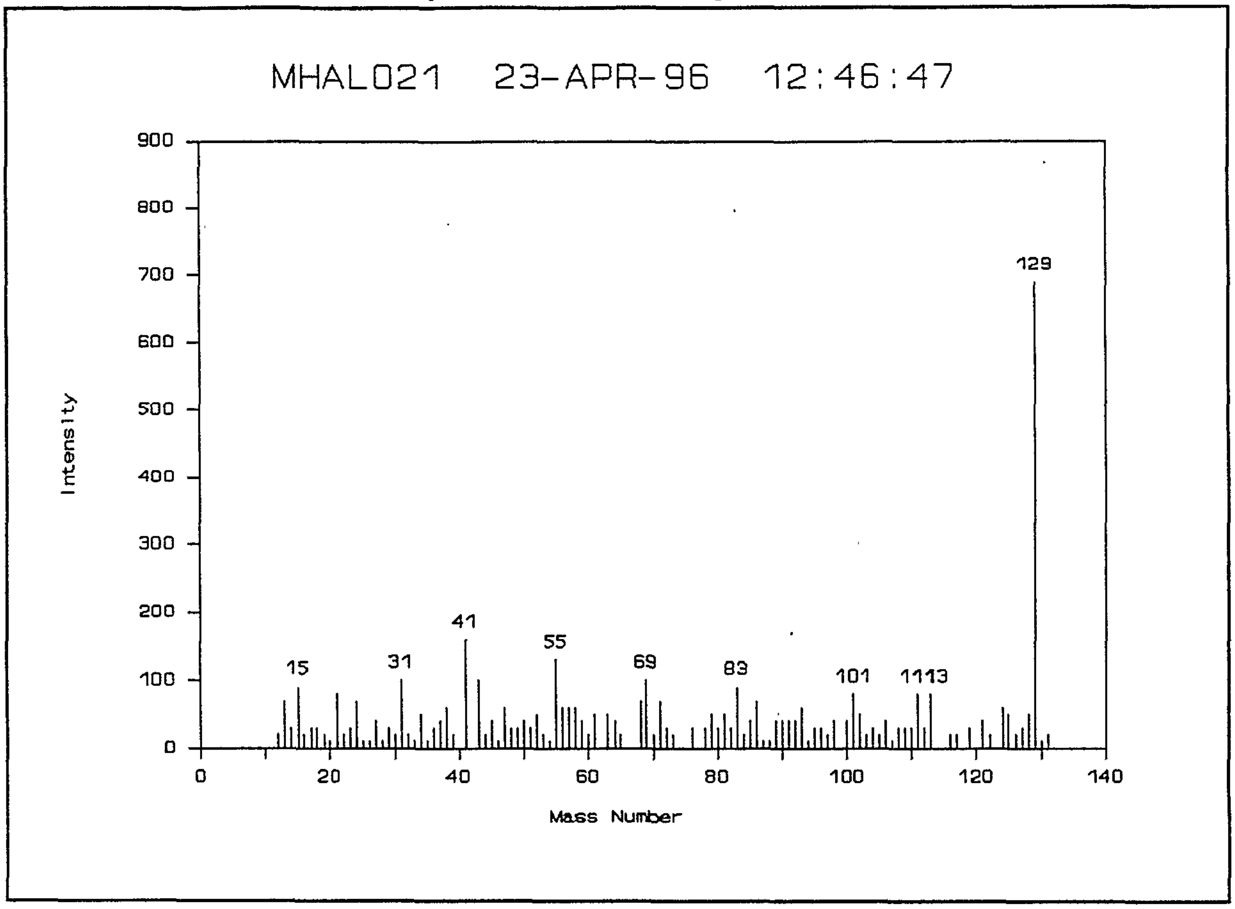

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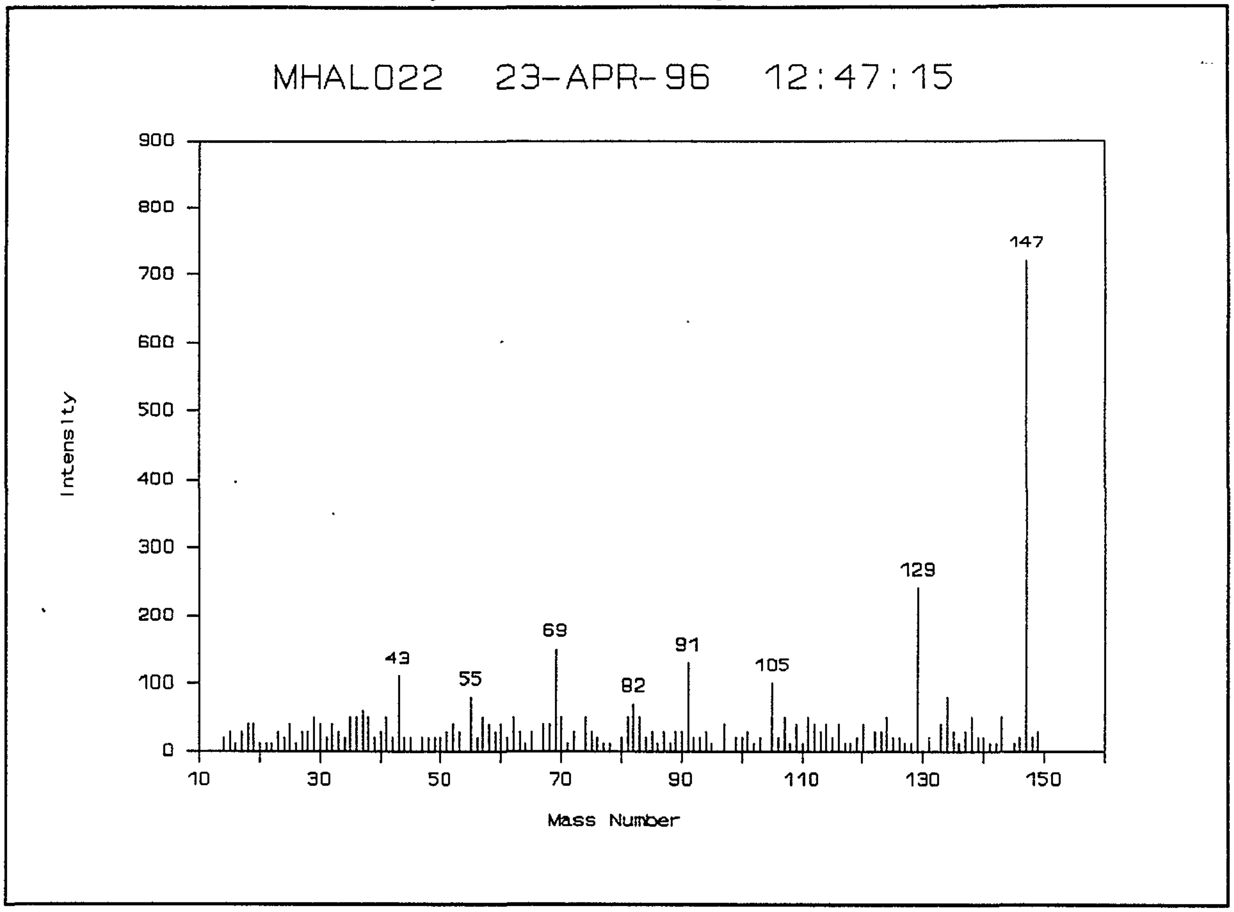
FIGURE 3k
Daughter Ion Spectrum (m/z = 147) at Pit 3
Halby Chemical Site, Wilmington, DE



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Pit 4

FIGURE 4a
Stationary Monitoring at Pit 4 for Vinyl Chloride, Benzene, and Ethylisothiocyanate
Halby Chemical Site, Wilmington, DE

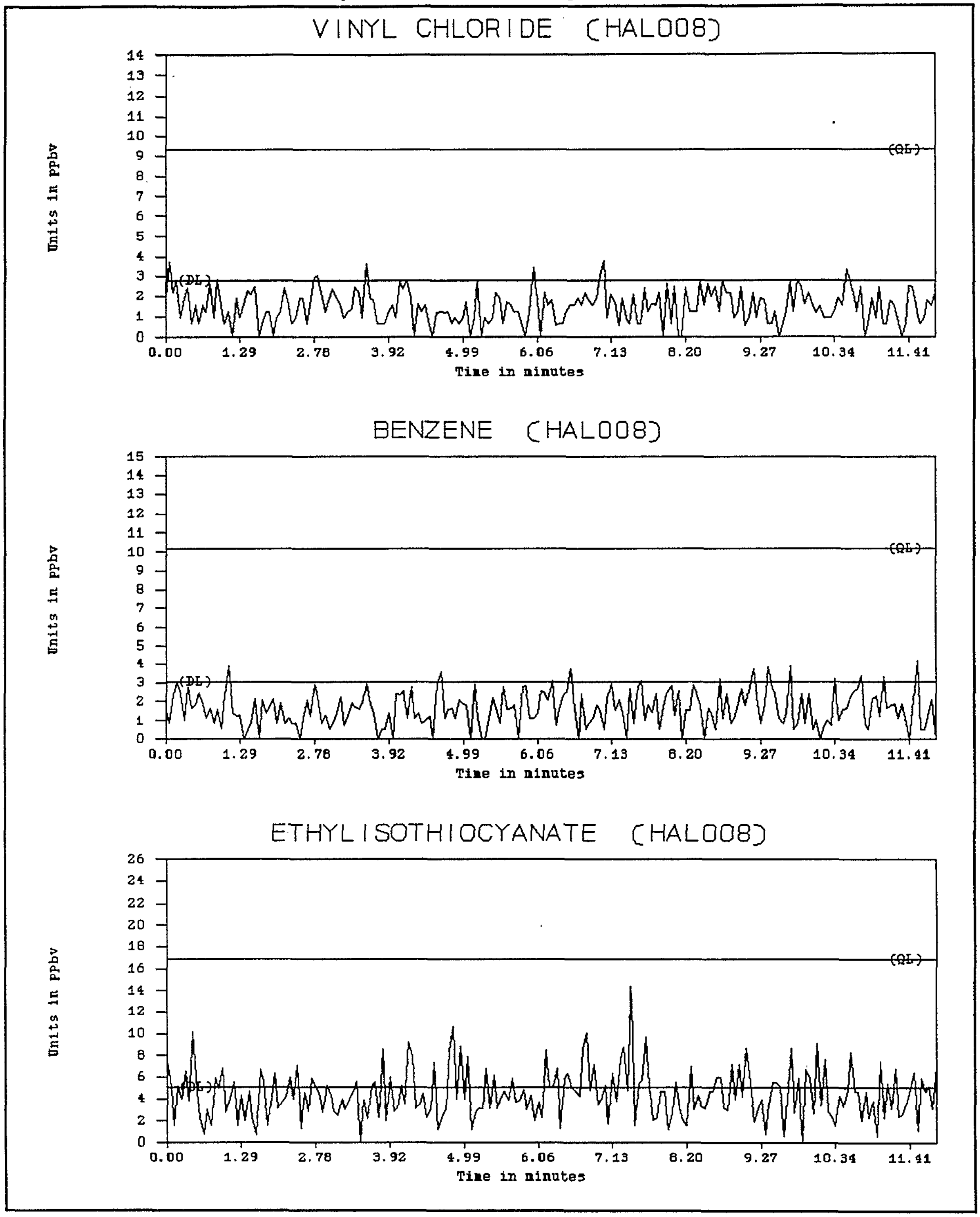

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FIGURE 4b
Stationary Monitoring at Pit 4 for Toluene, Trans-1,2-Dichloroethene, and Xylene
Halby Chemical Site, Wilmington, DE

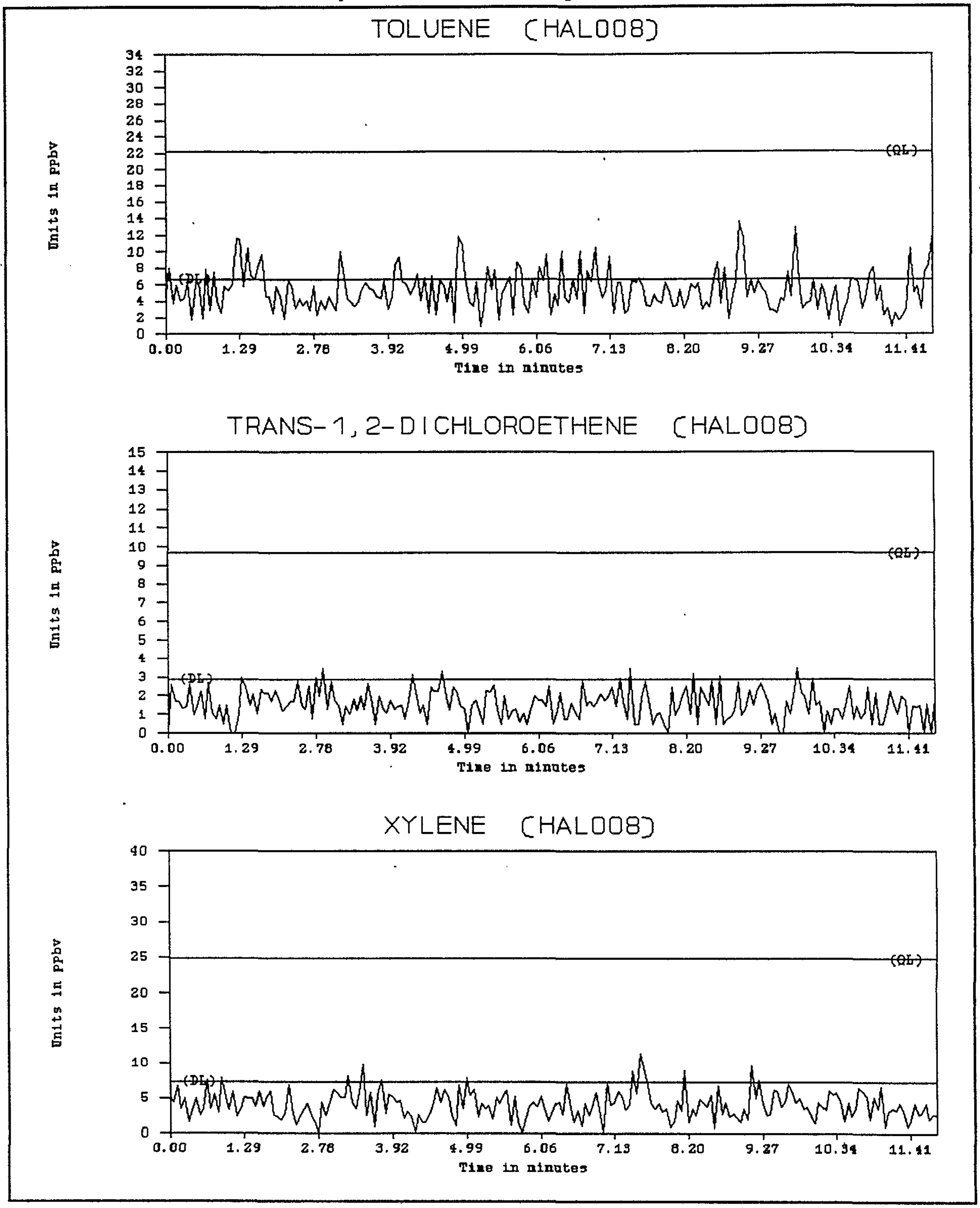

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FIGURE 4c
Stationary Monitoring at Pit 4 for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE

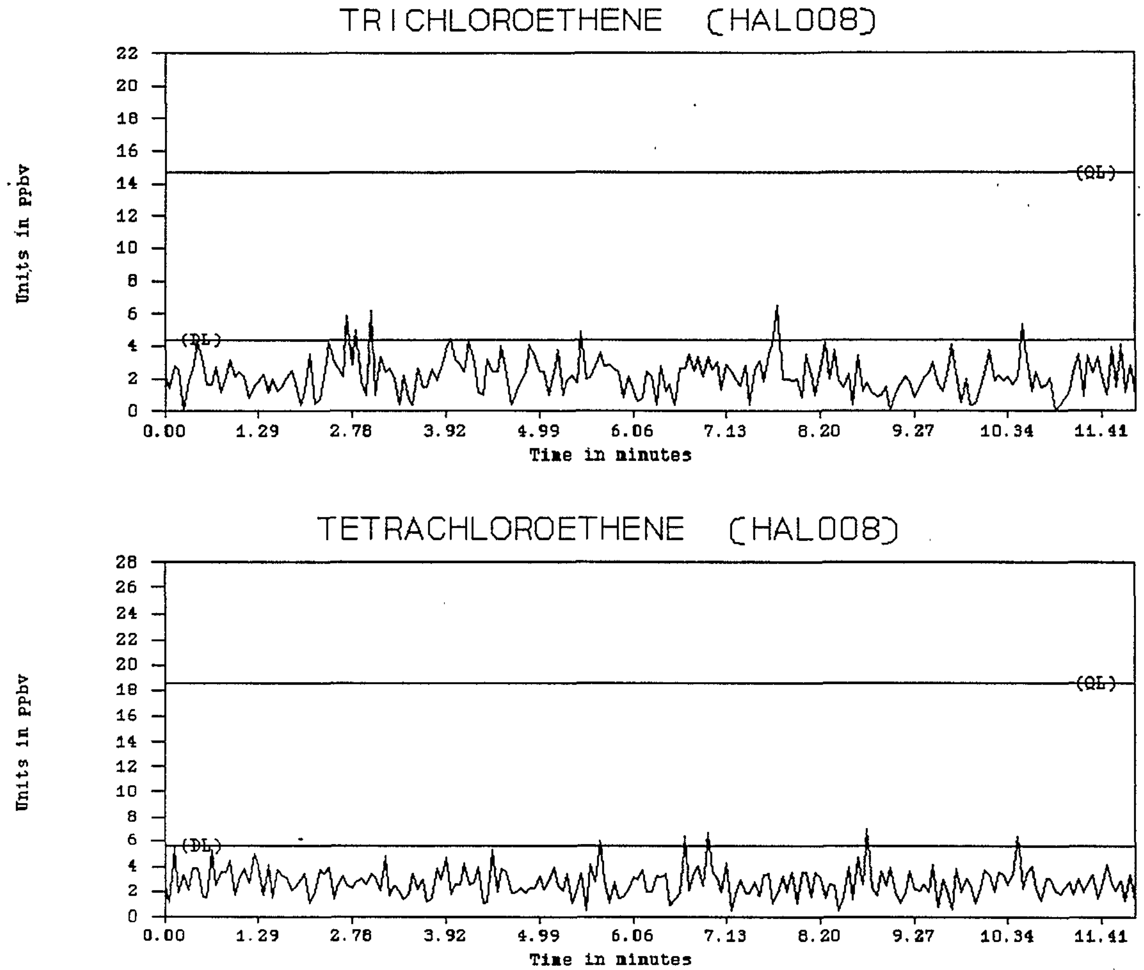

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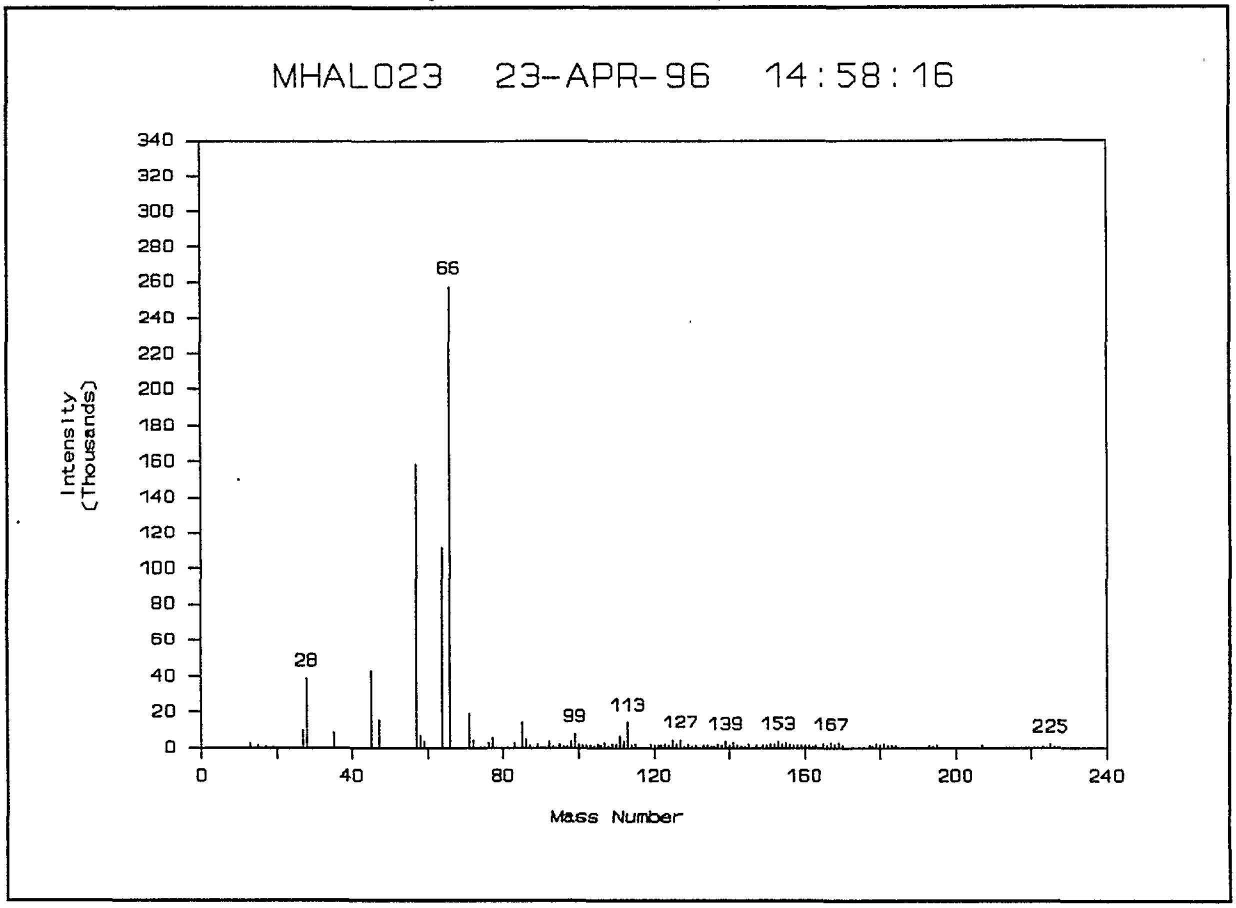
FIGURE 4d
Background Subtracted Parent Ion Spectrum at Pit 4
Halby Chemical Site, Wilmington, DE



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Pit 4 Extension

FIGURE 5a

Stationary Monitoring at Pit 4 Extension for Vinyl Chloride, Benzene, and Ethylisothiocyanate
Halby Chemical Site, Wilmington, DE

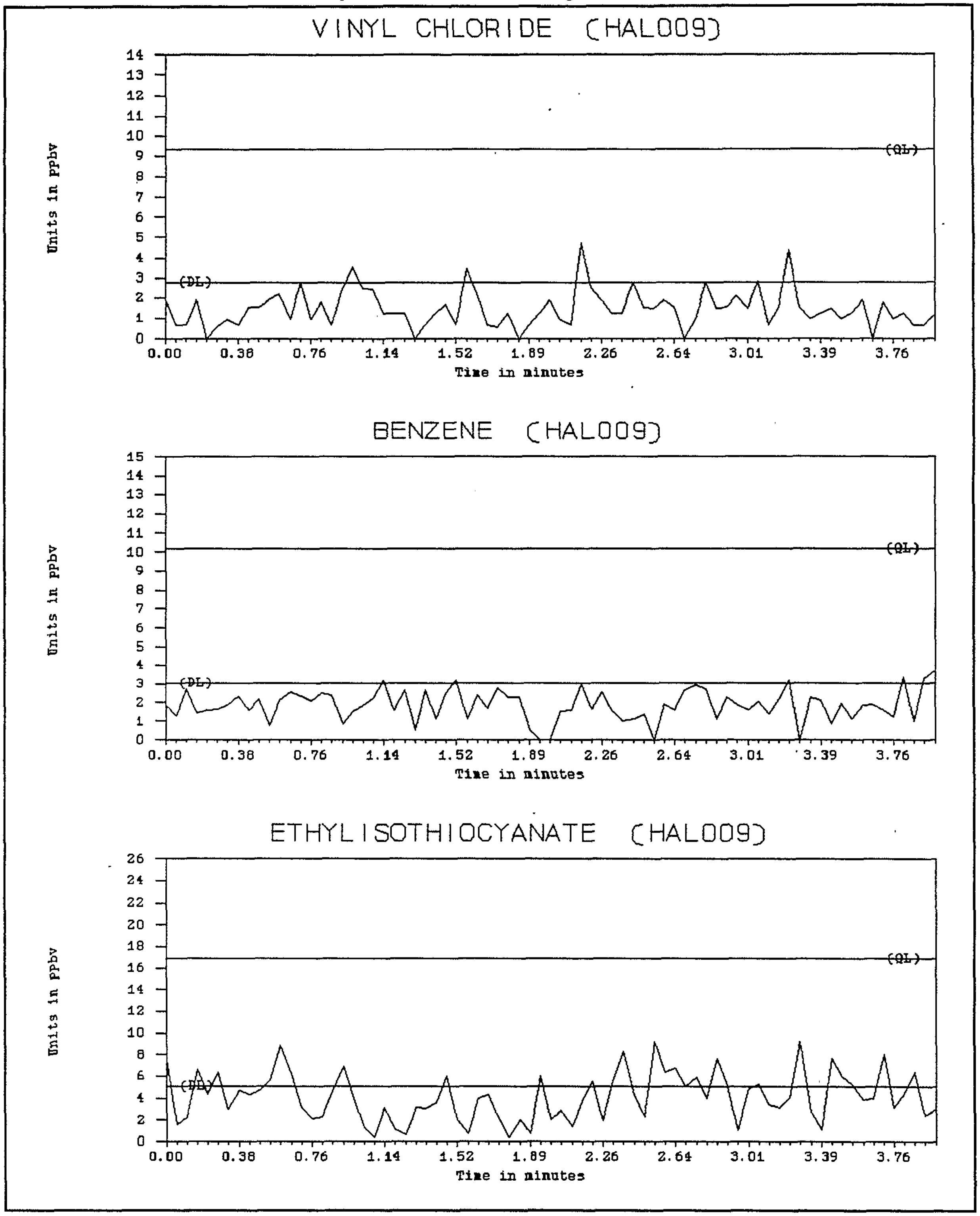

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FIGURE 5b

Stationary Monitoring at Pit 4 Extension for Toluene, Trans-1,2-Dichloroethene, and Xylene
Halby Chemical Site, Wilmington, DE

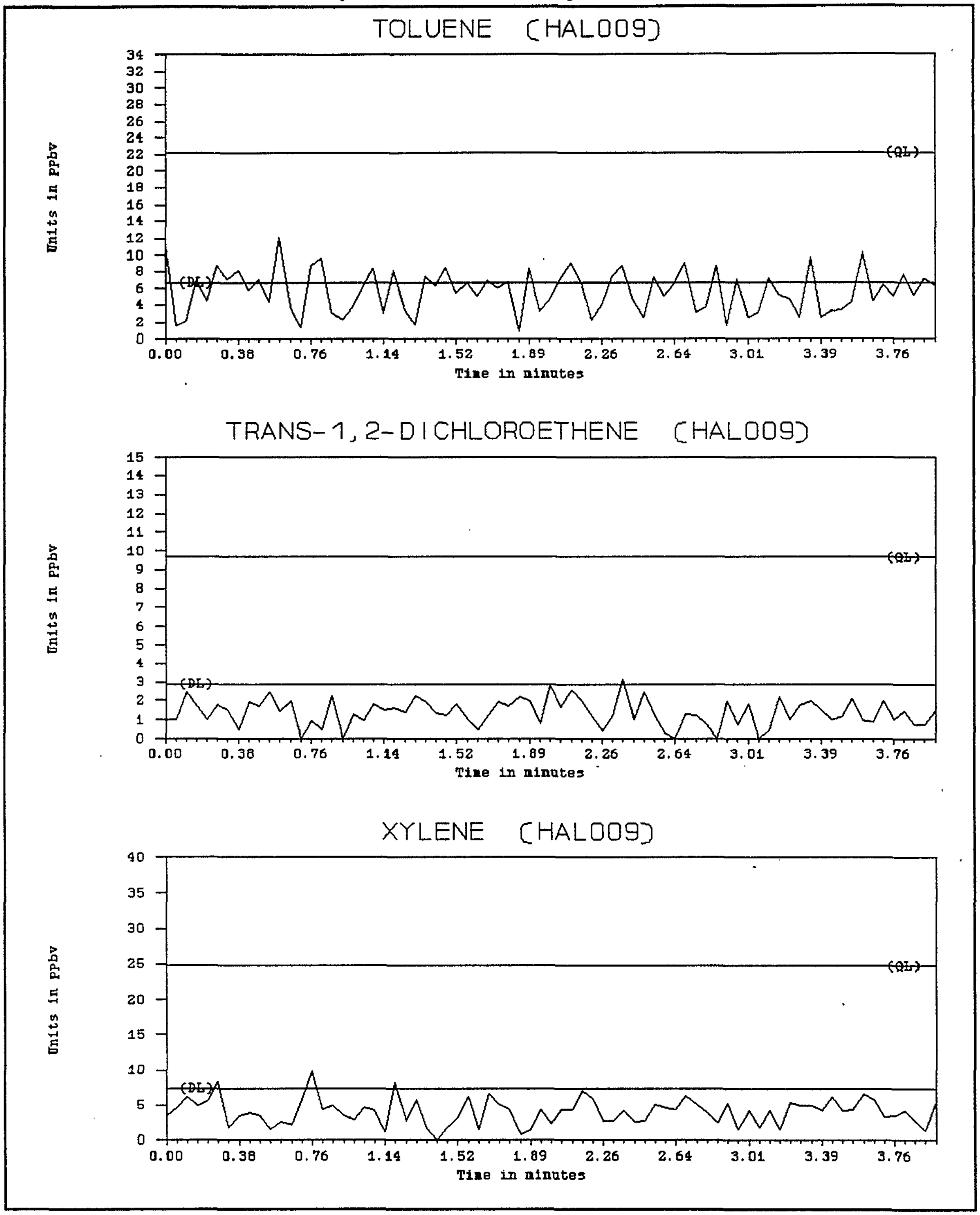

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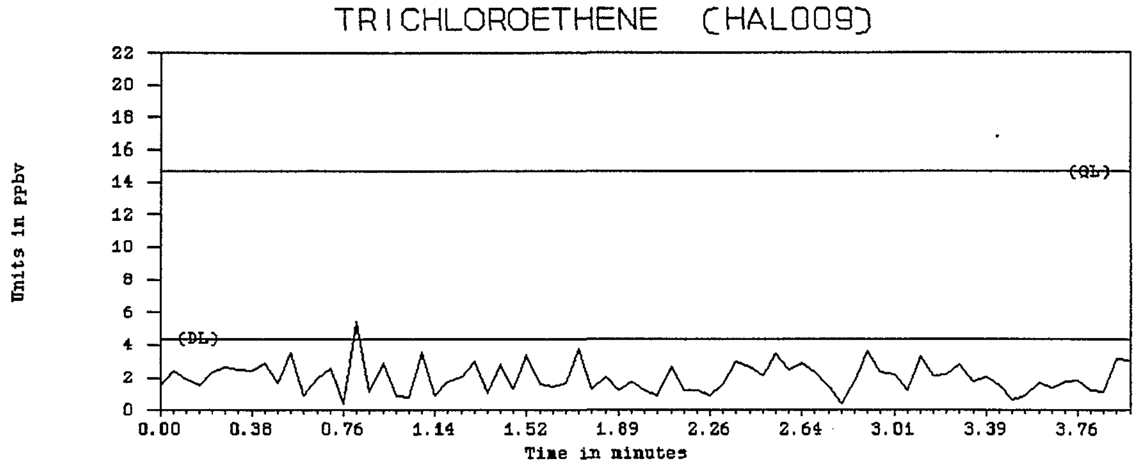
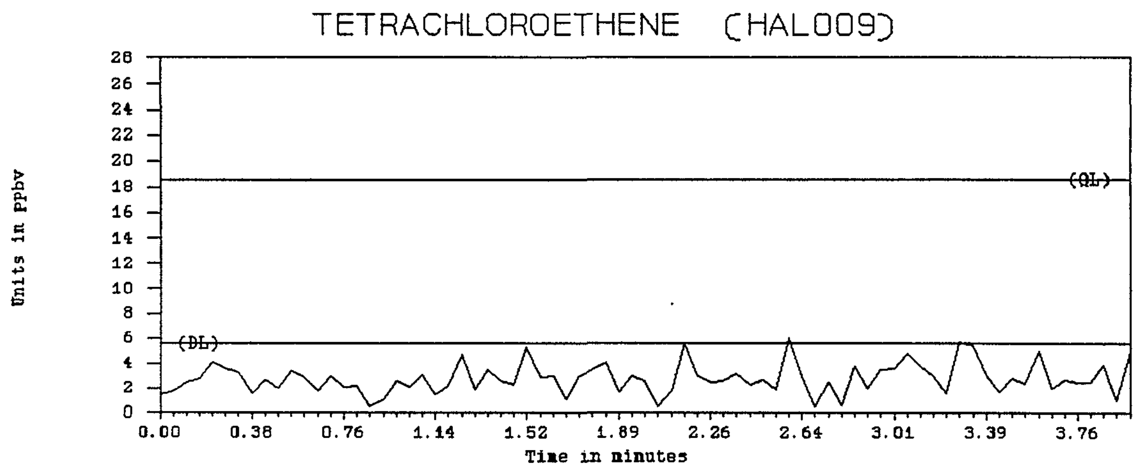
FIGURE 5c
Stationary Monitoring at Pit 4 Extension for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE





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Pit 1 Extension

FIGURE 6a
Stationary Monitoring at Pit 1 Extension for Vinyl Chloride, Benzene, and Ethylisothiocyanate
Halby Chemical Site, Wilmington, DE

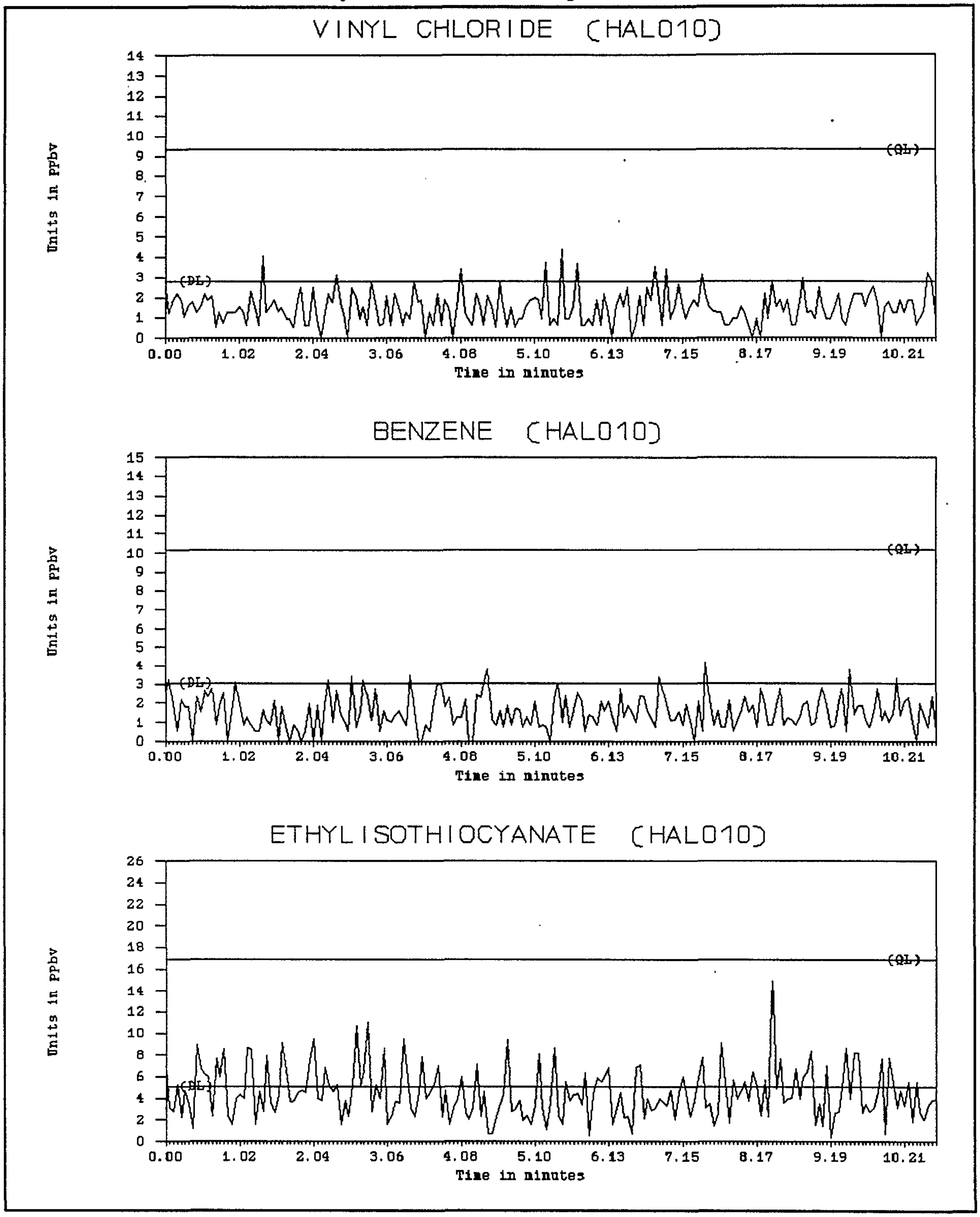

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FIGURE 6b
Stationary Monitoring at Pit 1 Extension for Toluene, Trans-1,2-Dichloroethene, and Xylene
Halby Chemical Site, Wilmington, DE

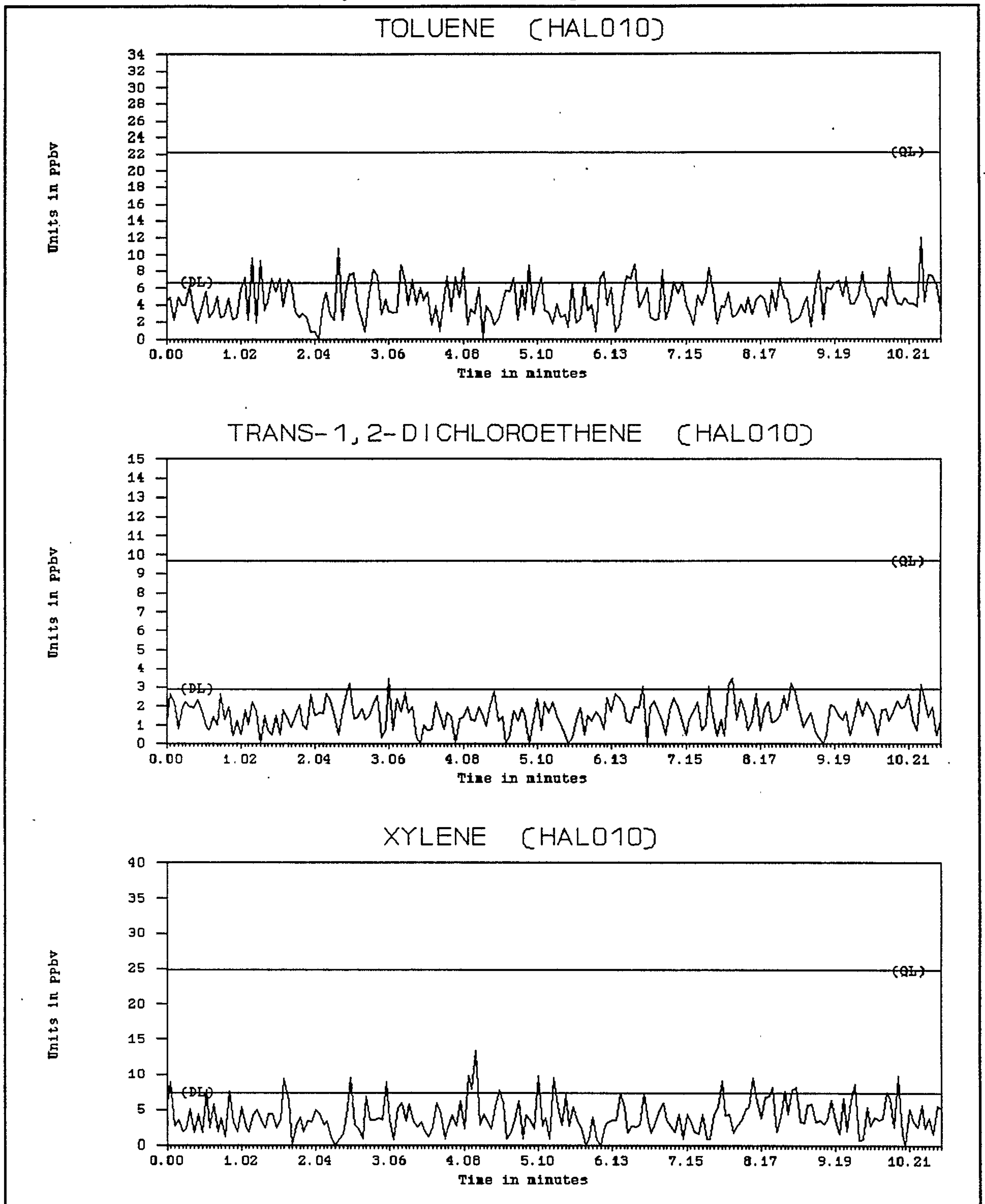

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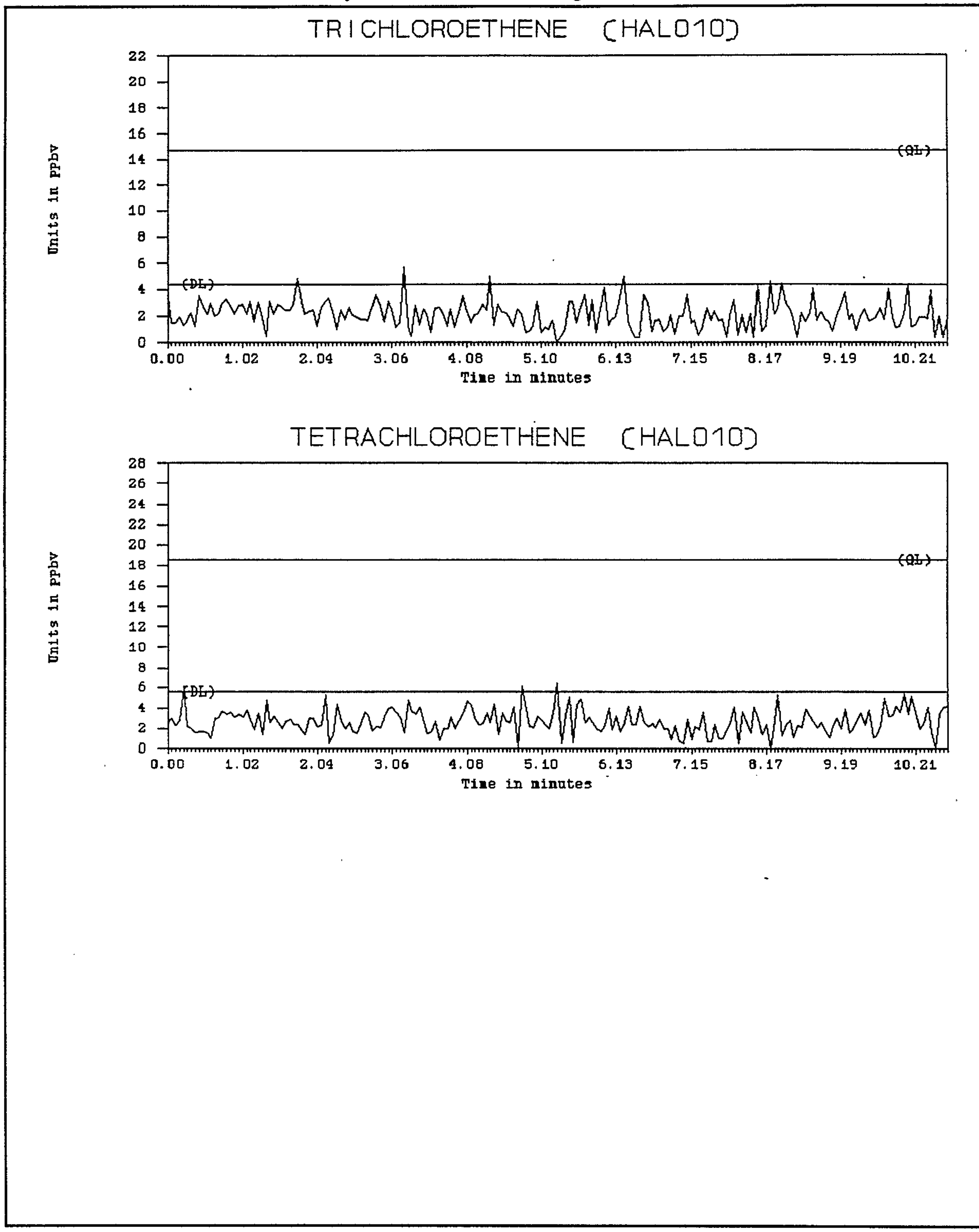
FIGURE 6c
Stationary Monitoring at Pit 1 Extension for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE



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Pit 1 Extension - Hose in the Pit

FIGURE 7a
Stationary Monitoring at Pit 1 Extension - Hose in the Pit
for Vinyl Chloride, Benzene, and Ethylisothiocyanate
Halby Chemical Site, Wilmington, DE

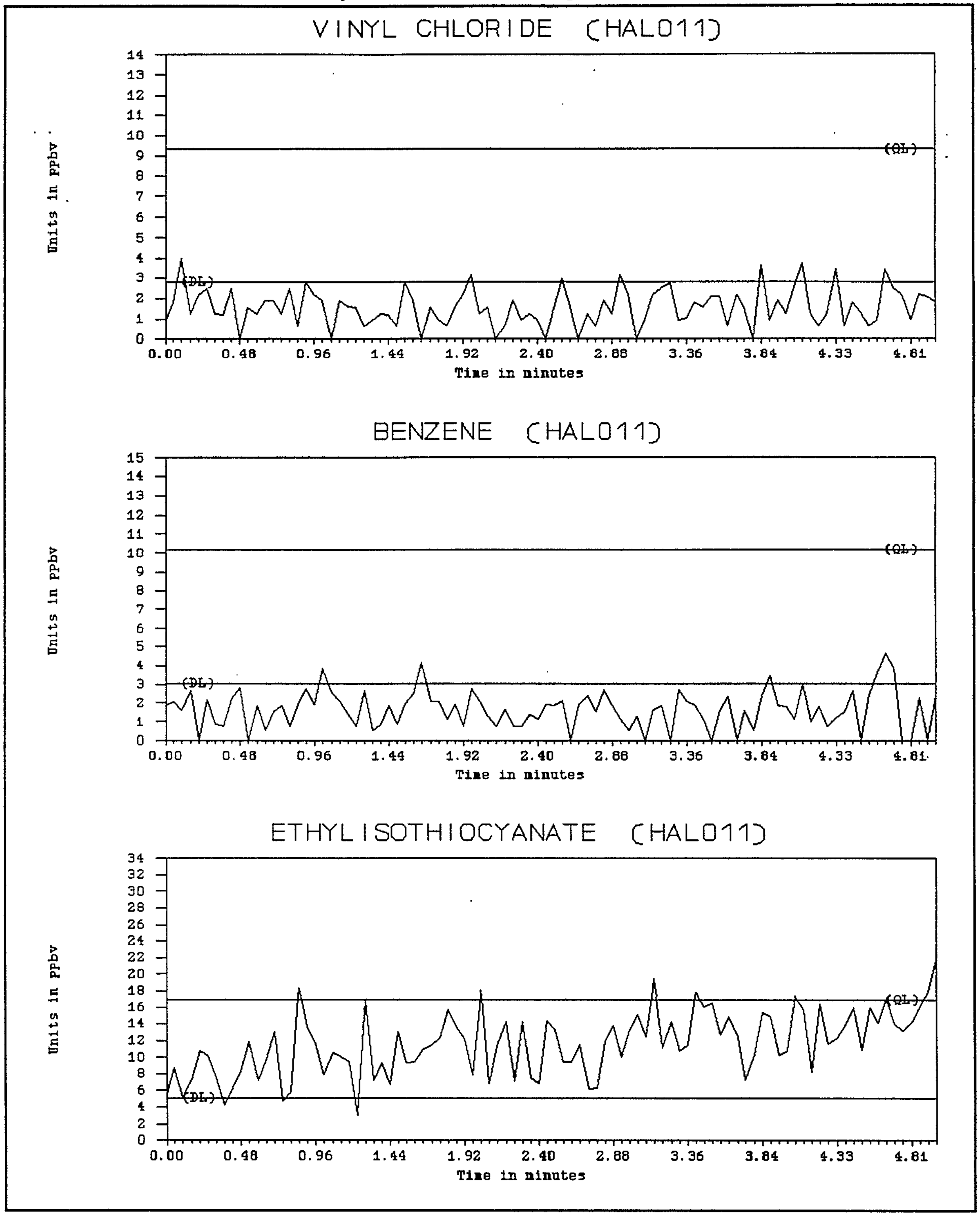

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FIGURE 7b
Stationary Monitoring at Pit 1 Extension - Hose in the Pit
for Toluene, Trans-1,2-Dichloroethene, and Xylene
Halby Chemical Site, Wilmington, DE

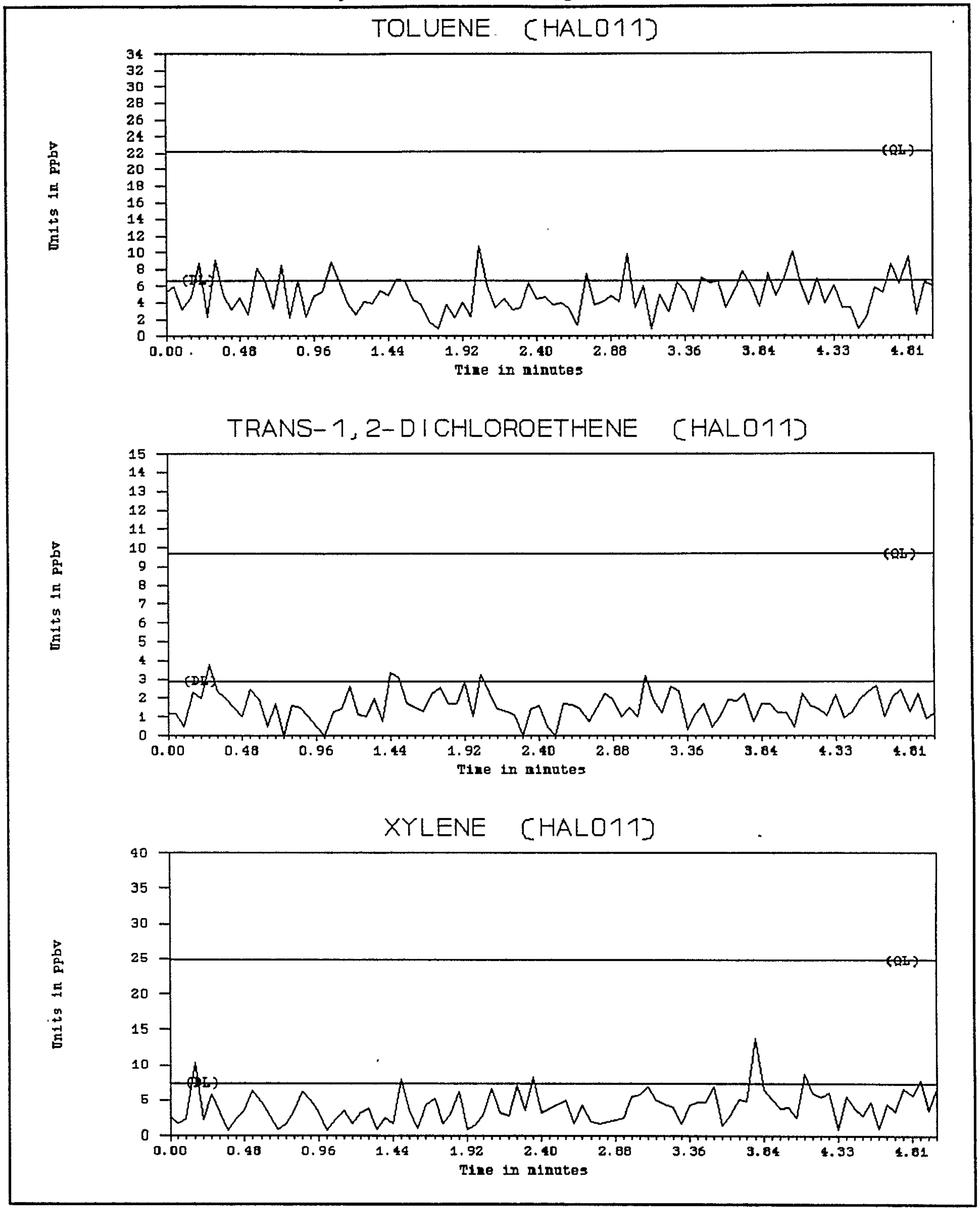

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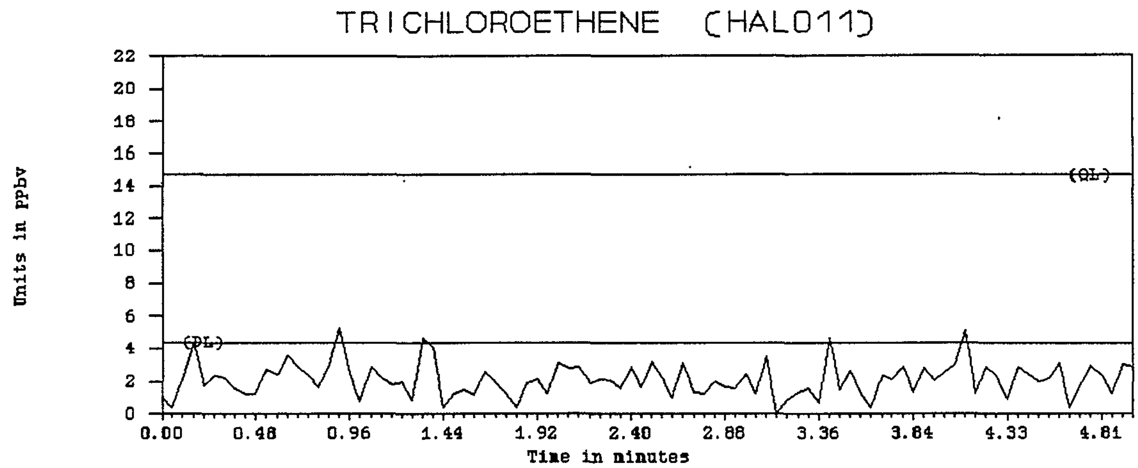
FIGURE 7c
Stationary Monitoring at Pit 1 Extension - Hose in the Pit
for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE



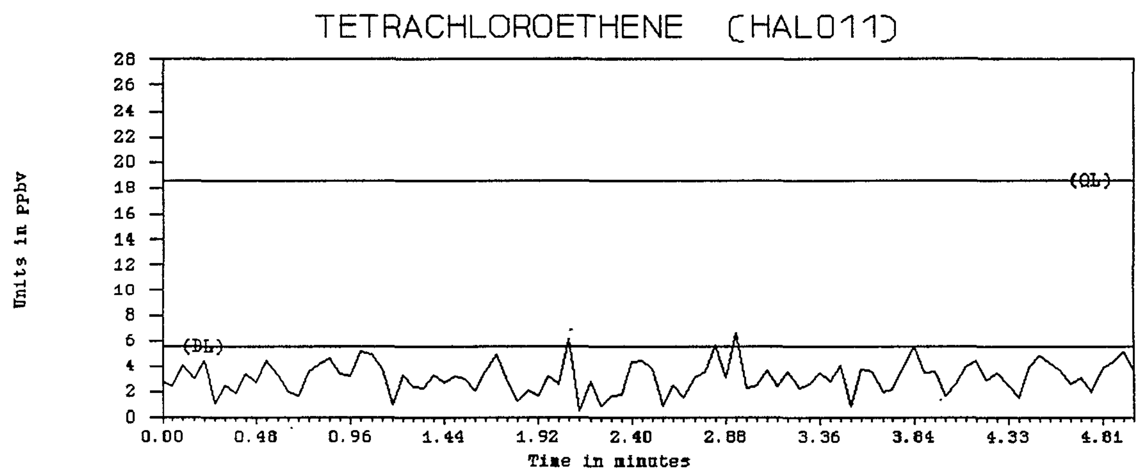


FIGURE 7d

Background Subtracted Parent Ion Spectrum at Pit 1 Extension - Hose in Pit

Halby Chemical Site, Wilmington, DE

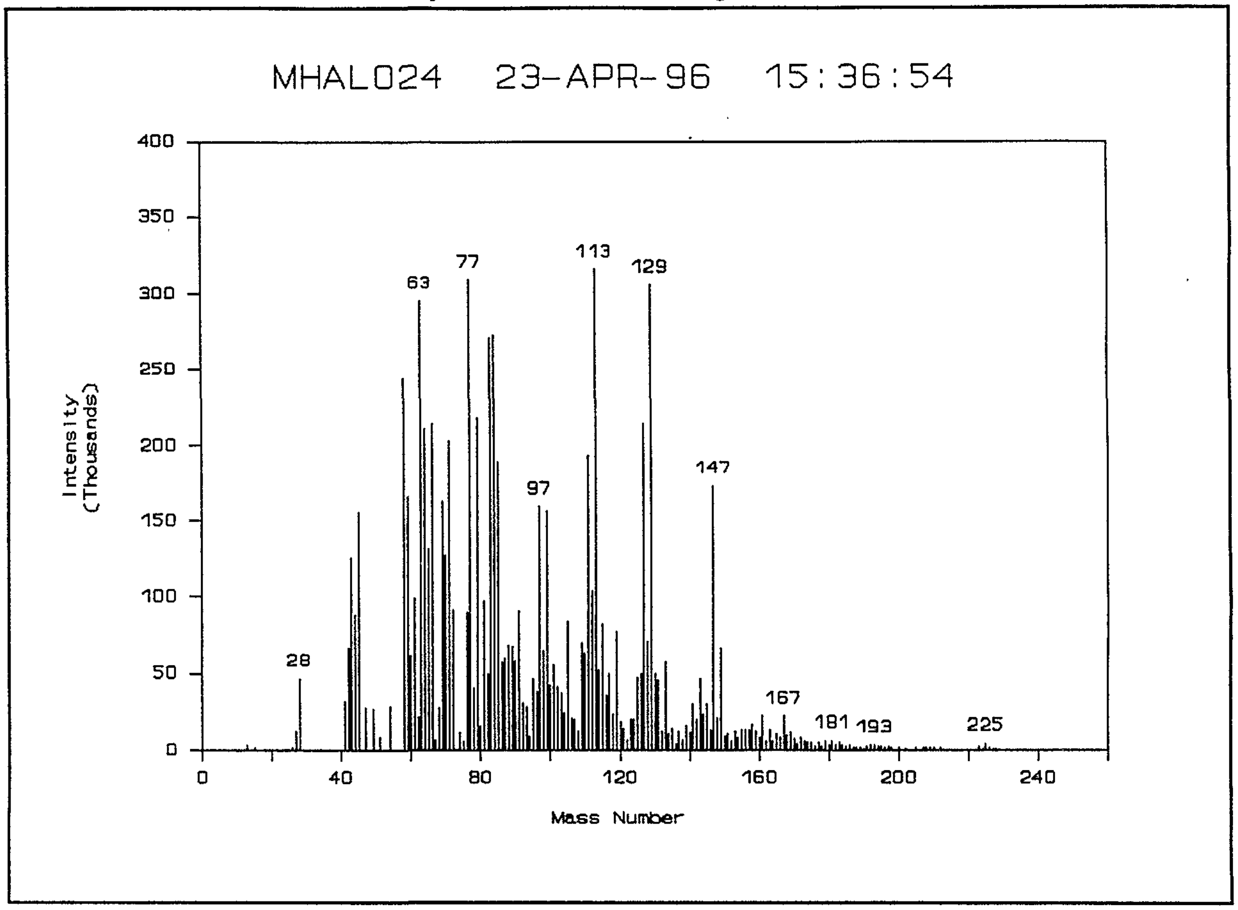


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FIGURE 7e
Daughter Ion Spectrum (m/z = 77) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

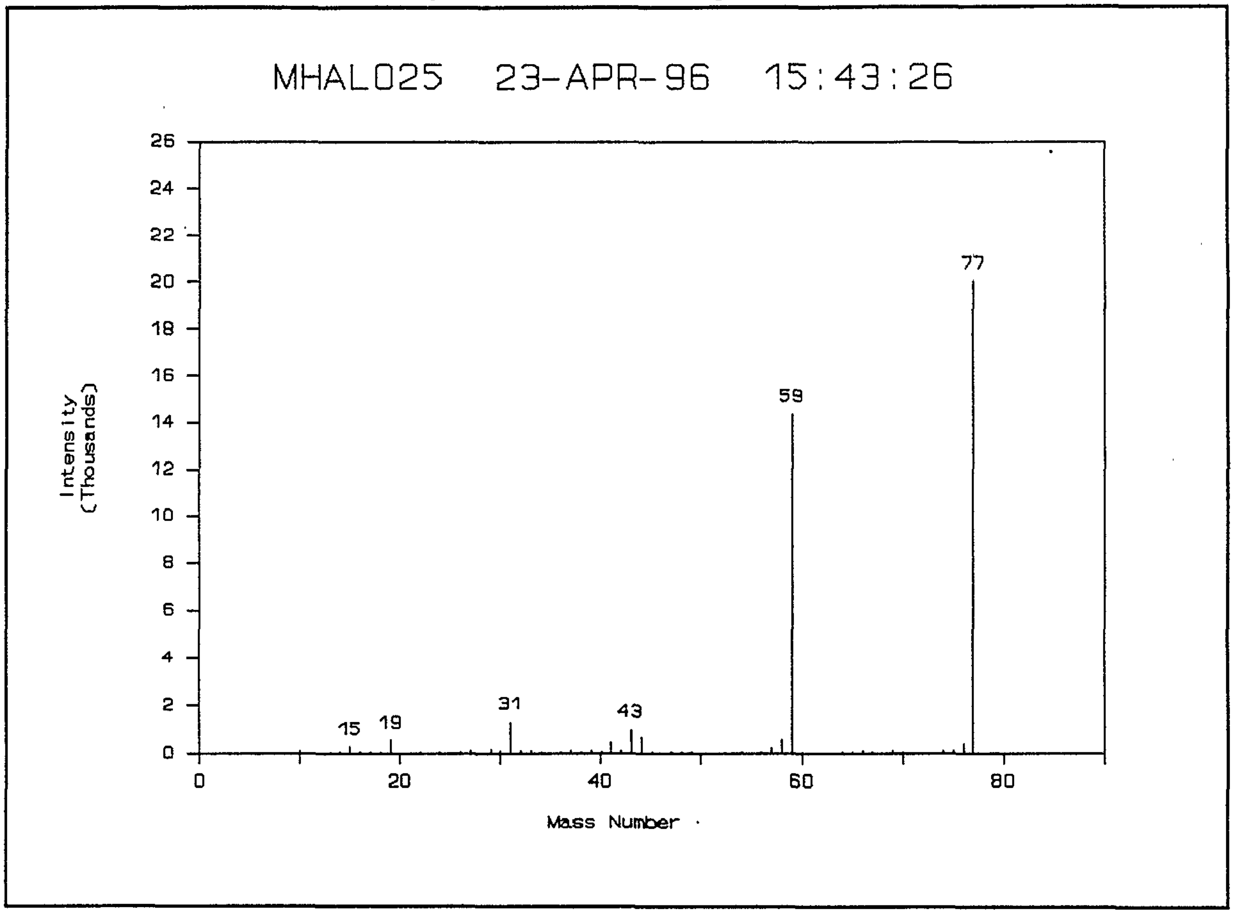

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FIGURE 7f
Daughter Ion Spectrum (m/z = 79) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

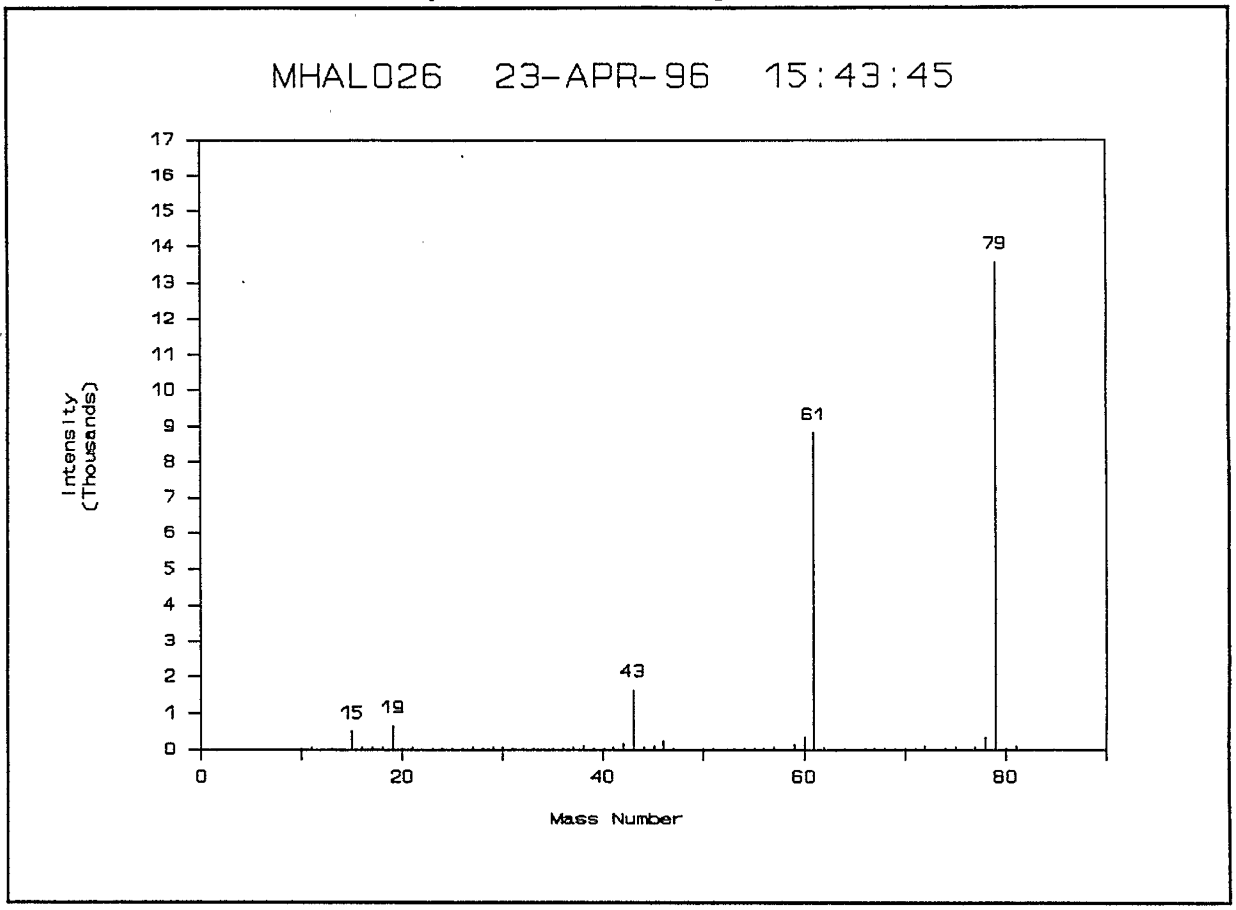

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FIGURE 7g
Daughter Ion Spectrum (m/z = 83) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

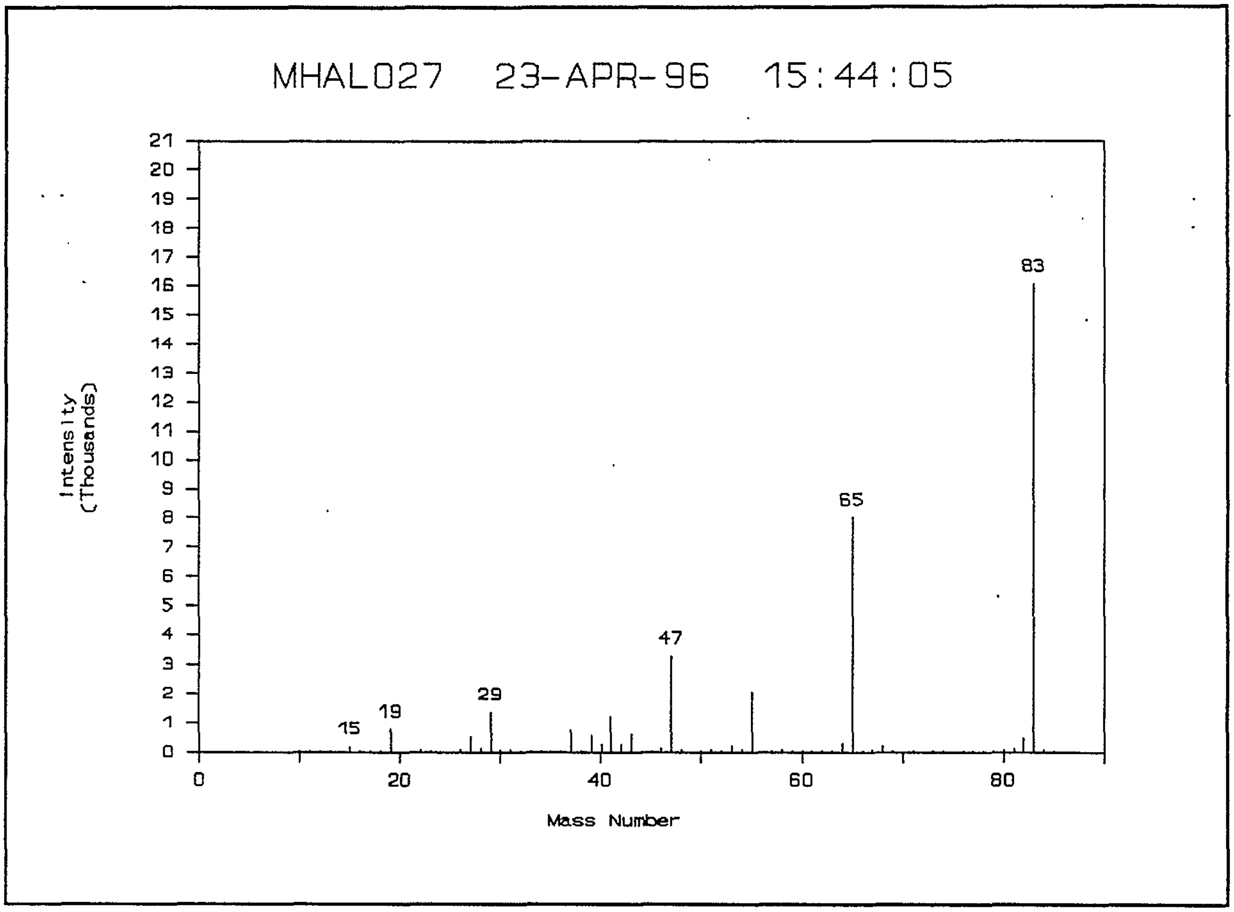

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FIGURE 7h
Daughter Ion Spectrum (m/z = 84) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

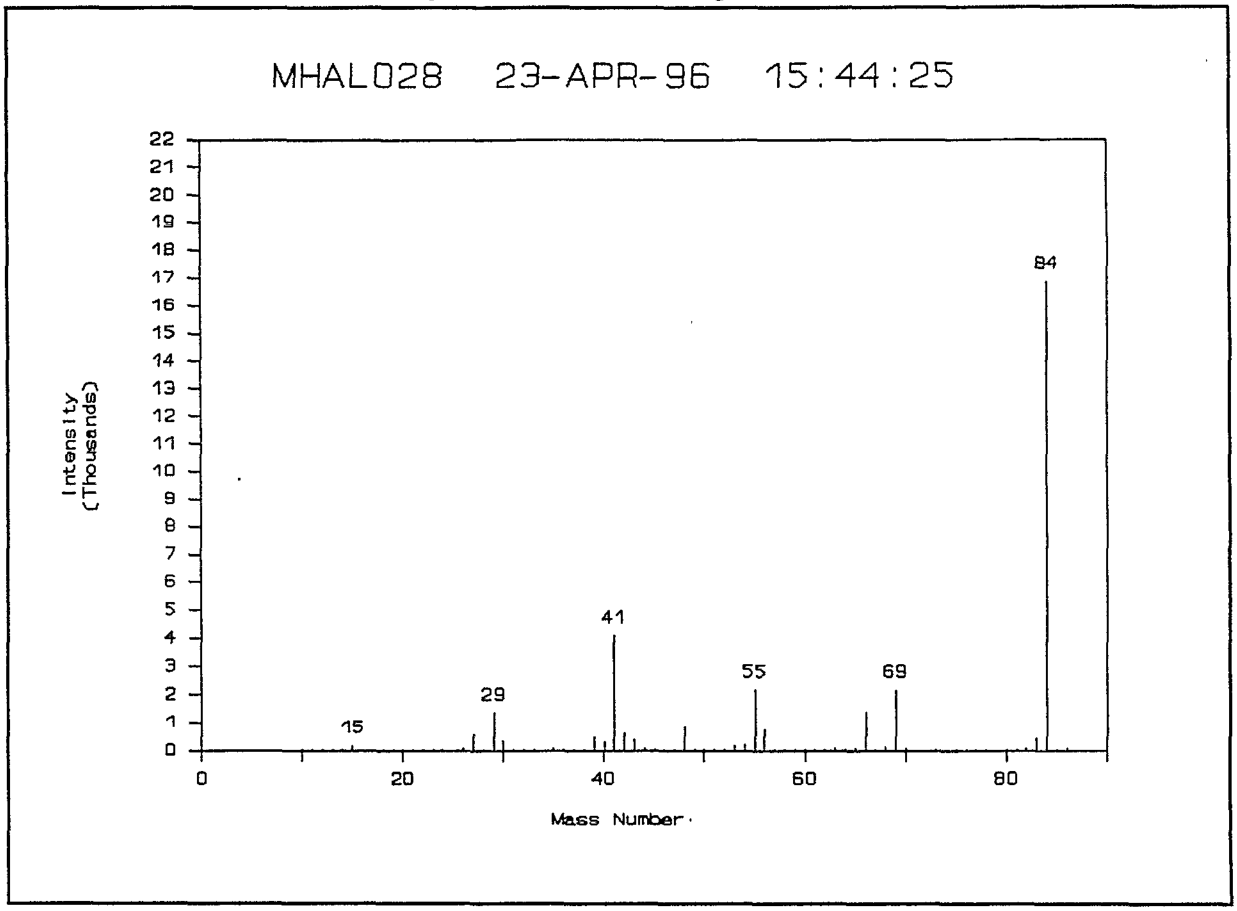

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FIGURE 7i
Daughter Ion Spectrum (m/z = 97) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

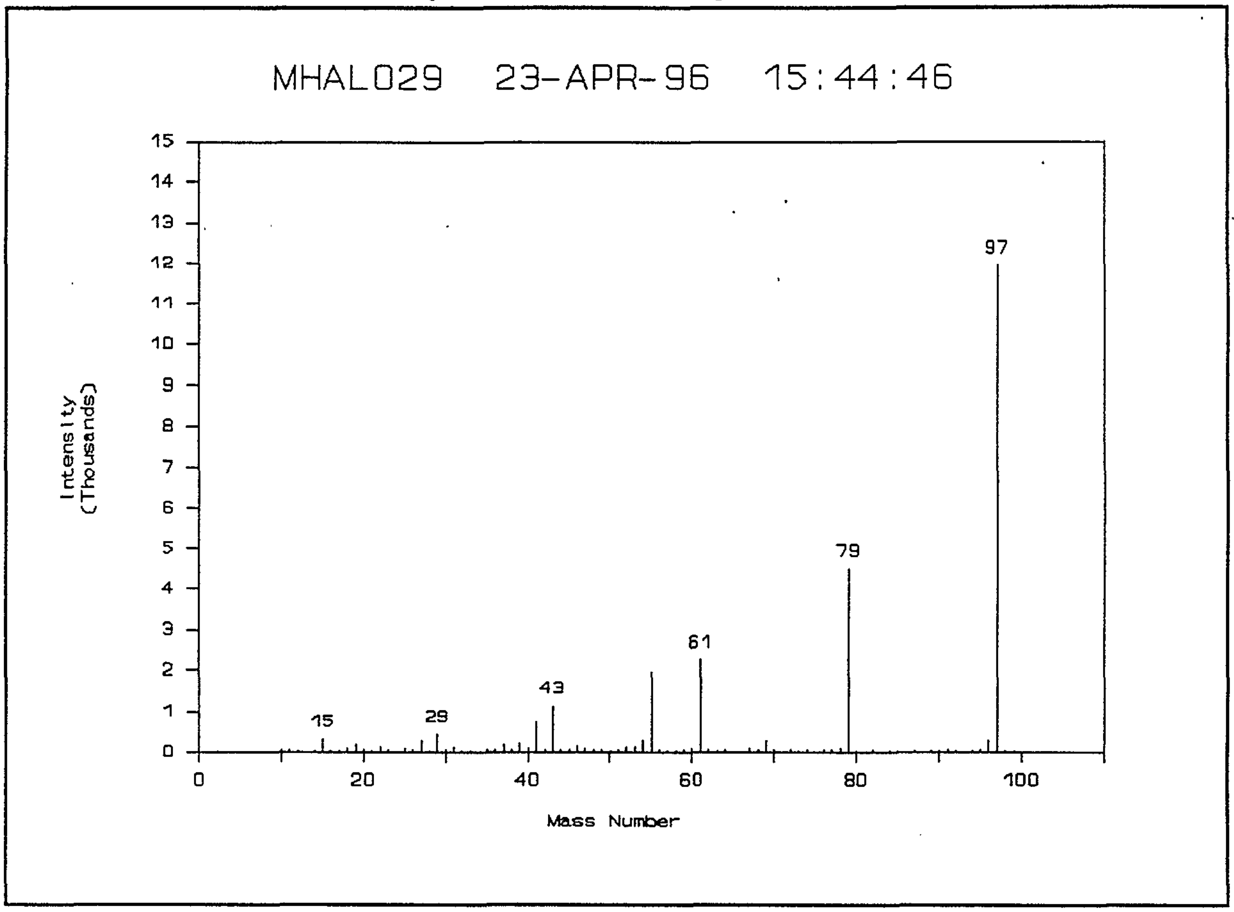

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FIGURE 7j
Daughter Ion Spectrum (m/z = 99) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

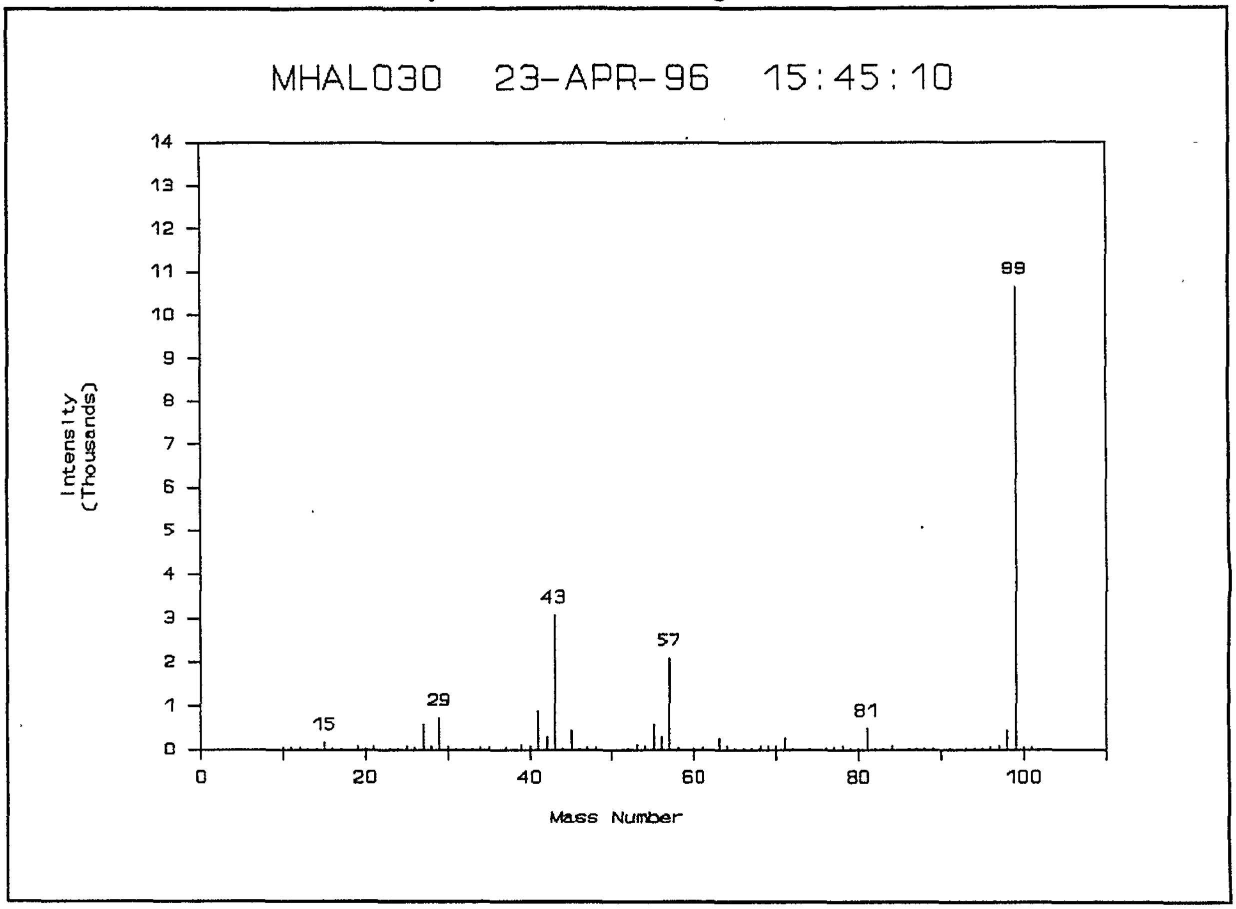

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FIGURE 7k
Daughter Ion Spectrum (m/z = 111) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

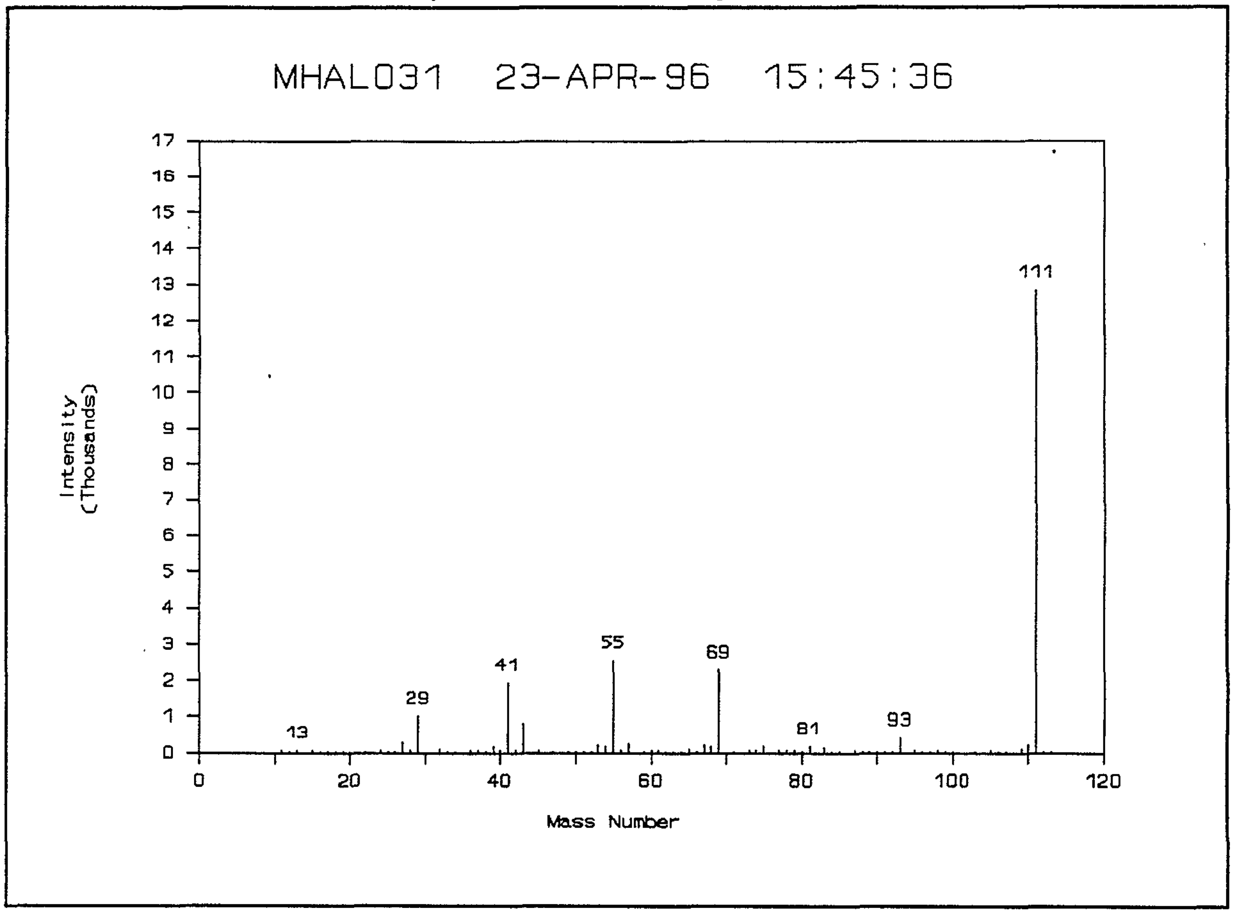

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FIGURE 71
Daughter Ion Spectrum (m/z = 113) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

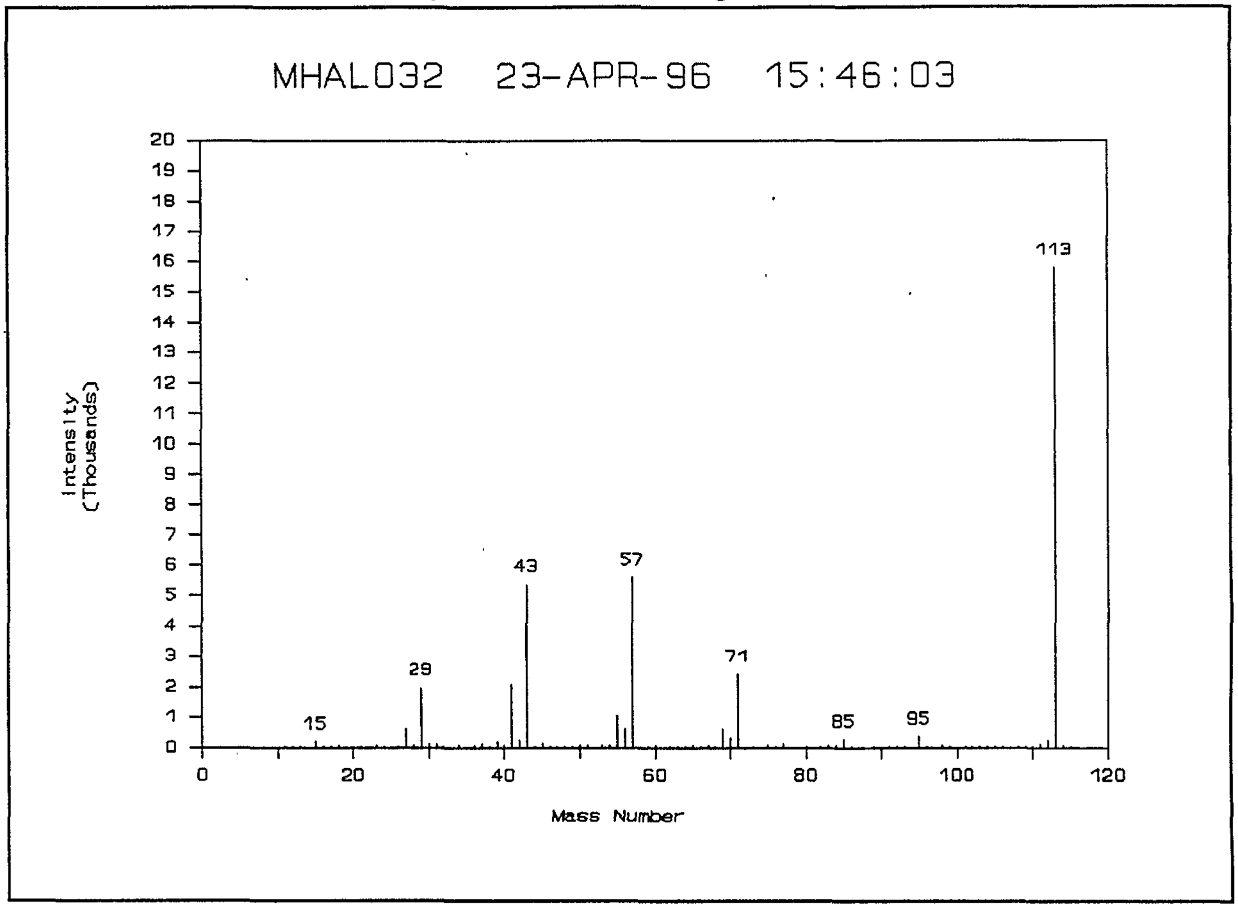

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FIGURE 7m
Daughter Ion Spectrum (m/z = 127) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

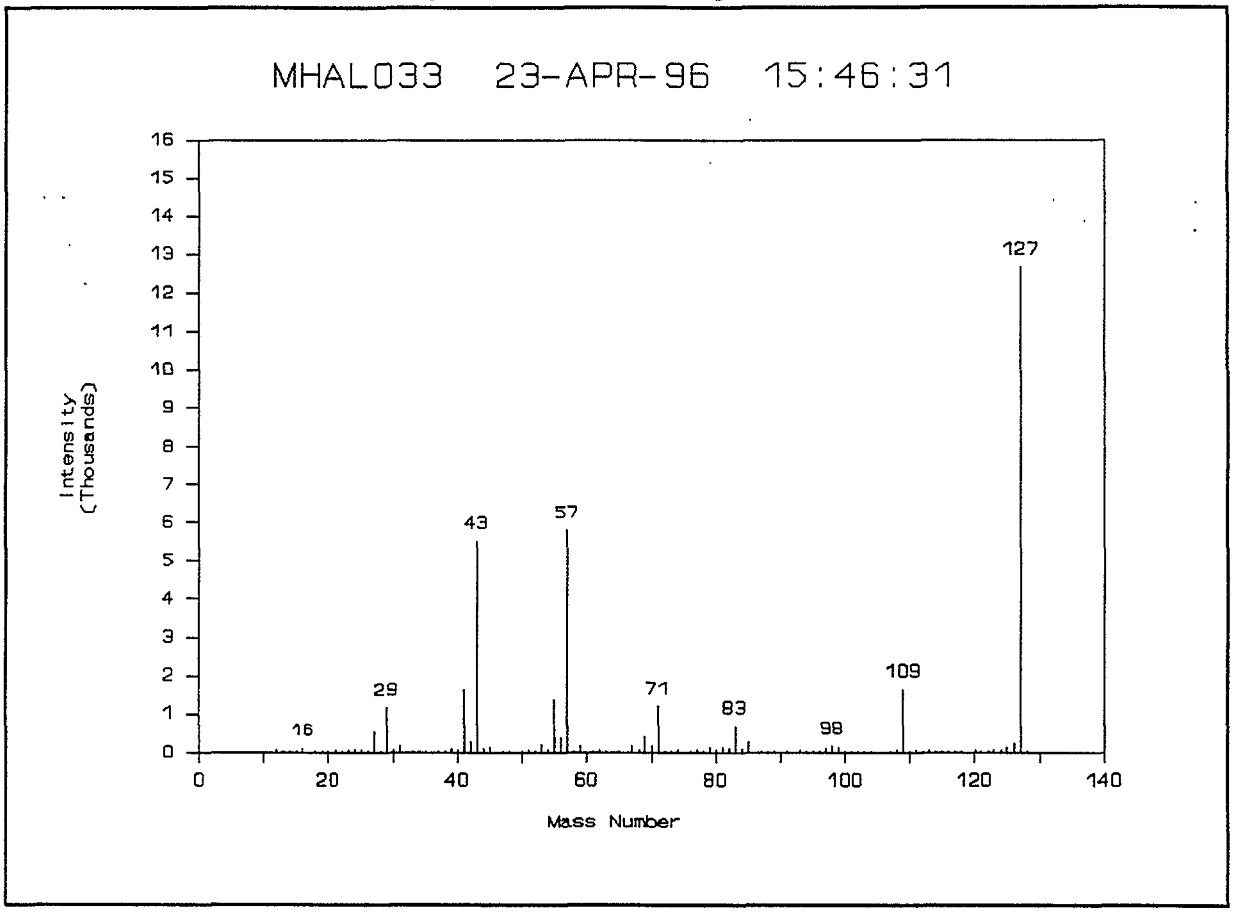

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FIGURE 7n
Daughter Ion Spectrum (m/z = 129) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

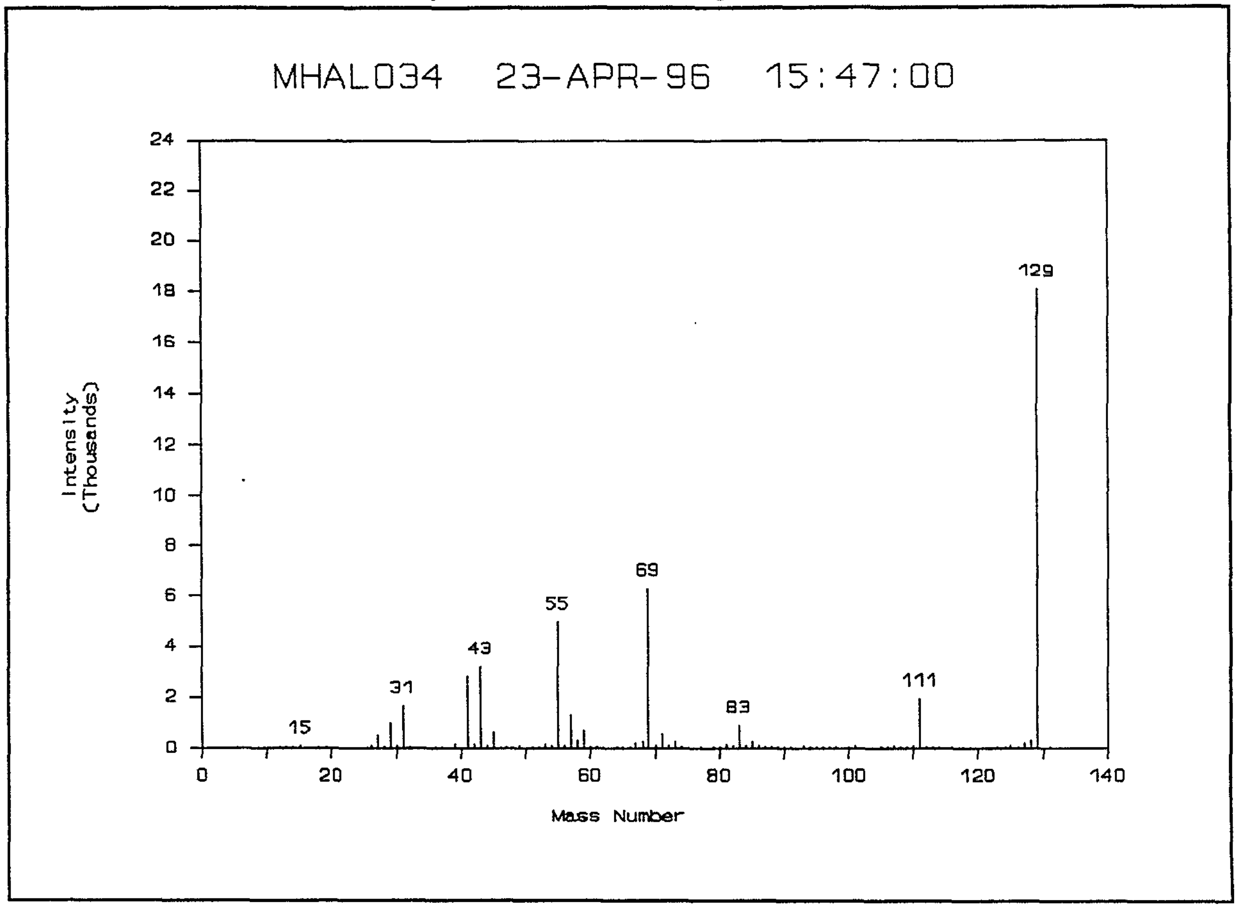

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FIGURE 7o
Daughter Ion Spectrum (m/z = 147) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

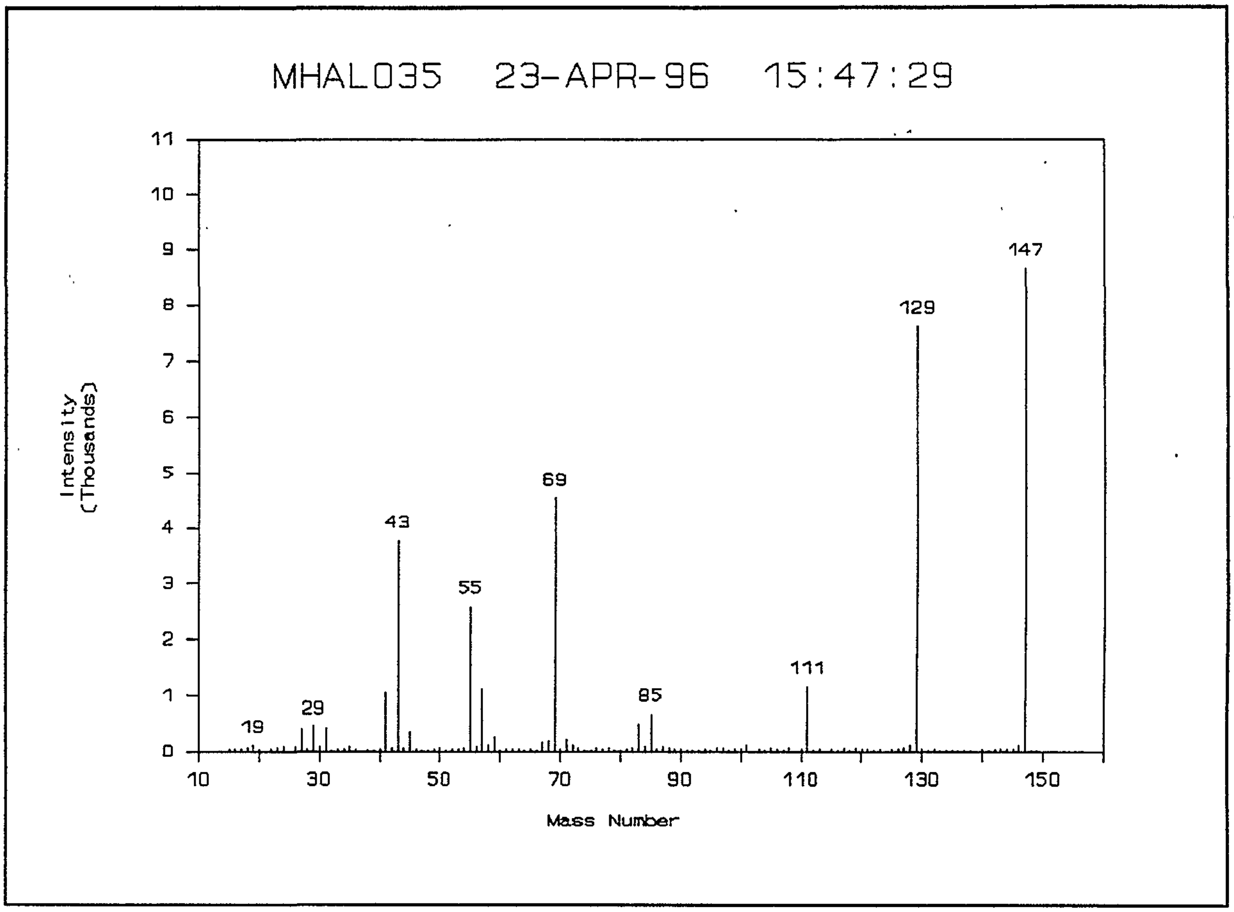
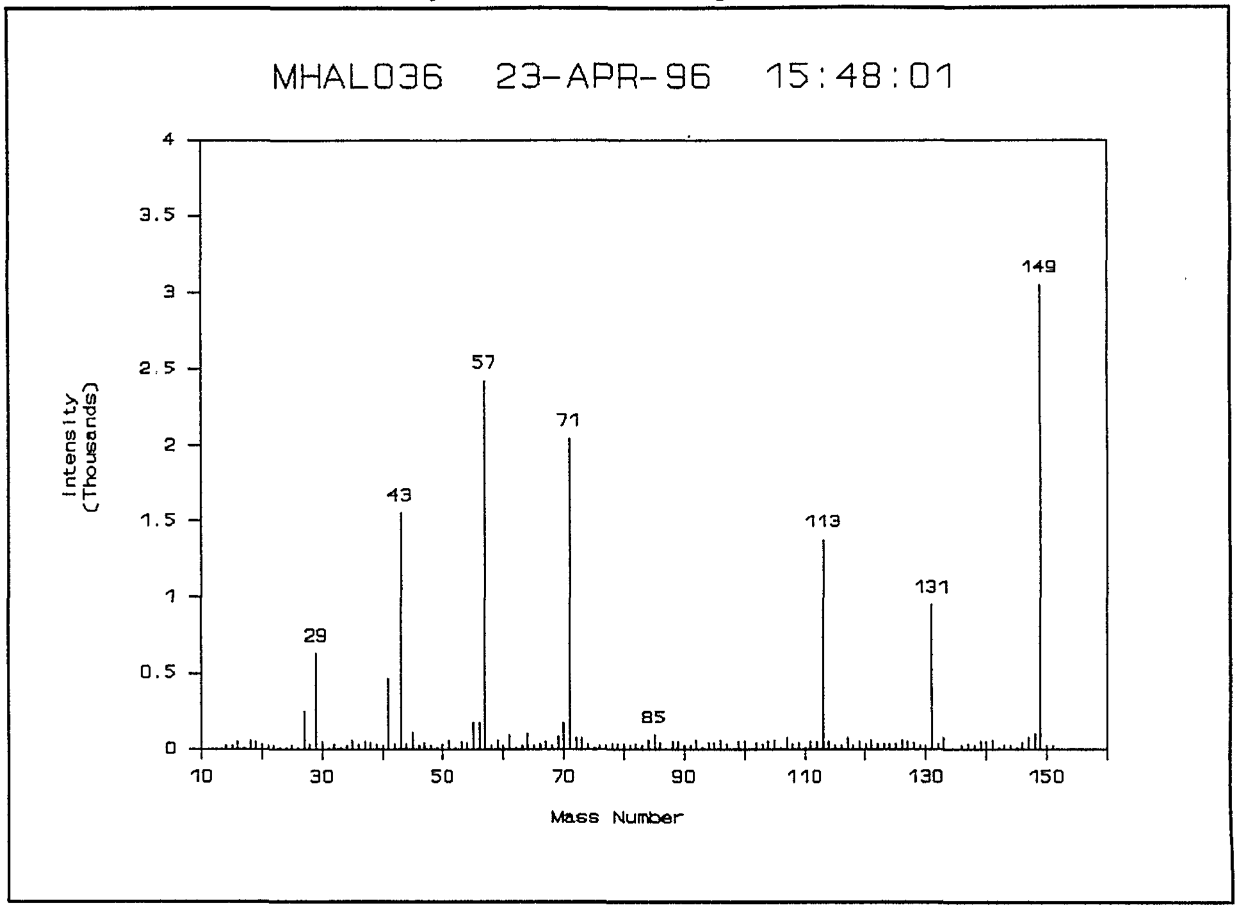


FIGURE 7p
Daughter Ion Spectrum (m/z = 149) at Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE



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Pit 2 Extension - Hose in the Pit

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FIGURE 8a
Stationary Monitoring at Pit 2 Extension - Hose in the Pit
for Vinyl Chloride, Benzene, and Ethylisothiocyanate
Halby Chemical Site, Wilmington, DE

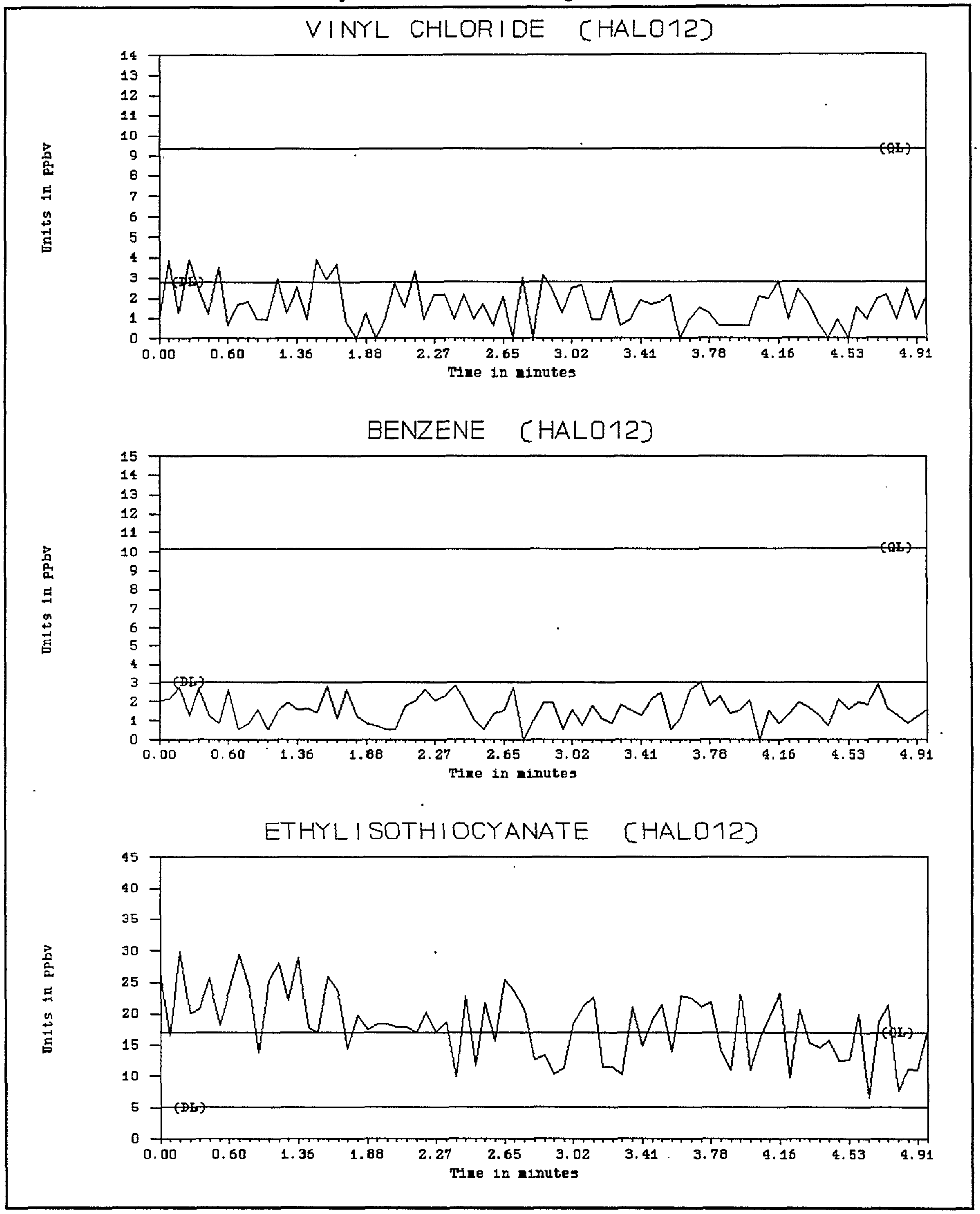

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FIGURE 8b
Stationary Monitoring at Pit 2 Extension - Hose in the Pit for Toluene, Trans-1,2-Dichloroethene, and Xylene Halby Chemical Site, Wilmington, DE

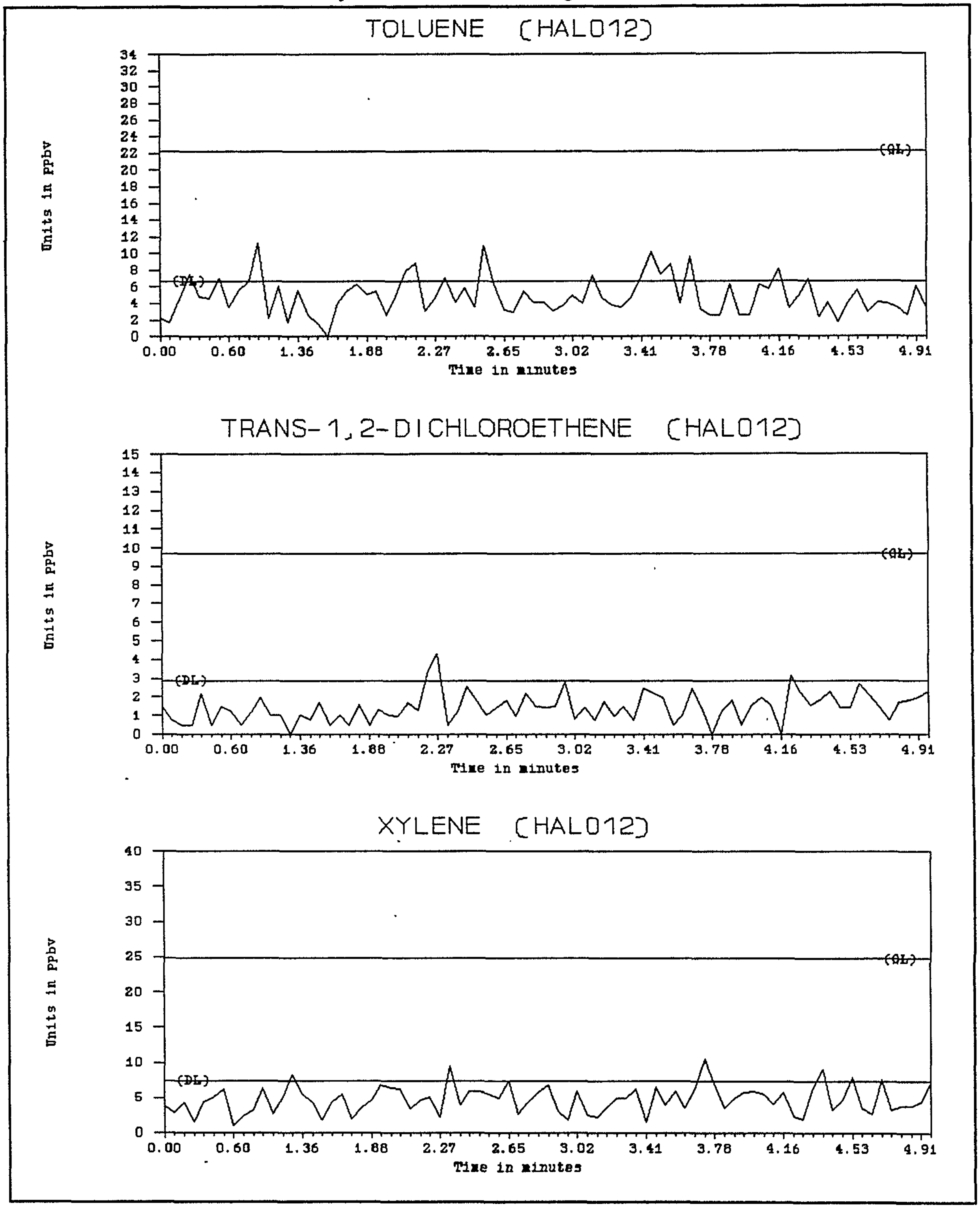

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FIGURE 8c
Stationary Monitoring at Pit 2 Extension - Hose in the Pit
for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE

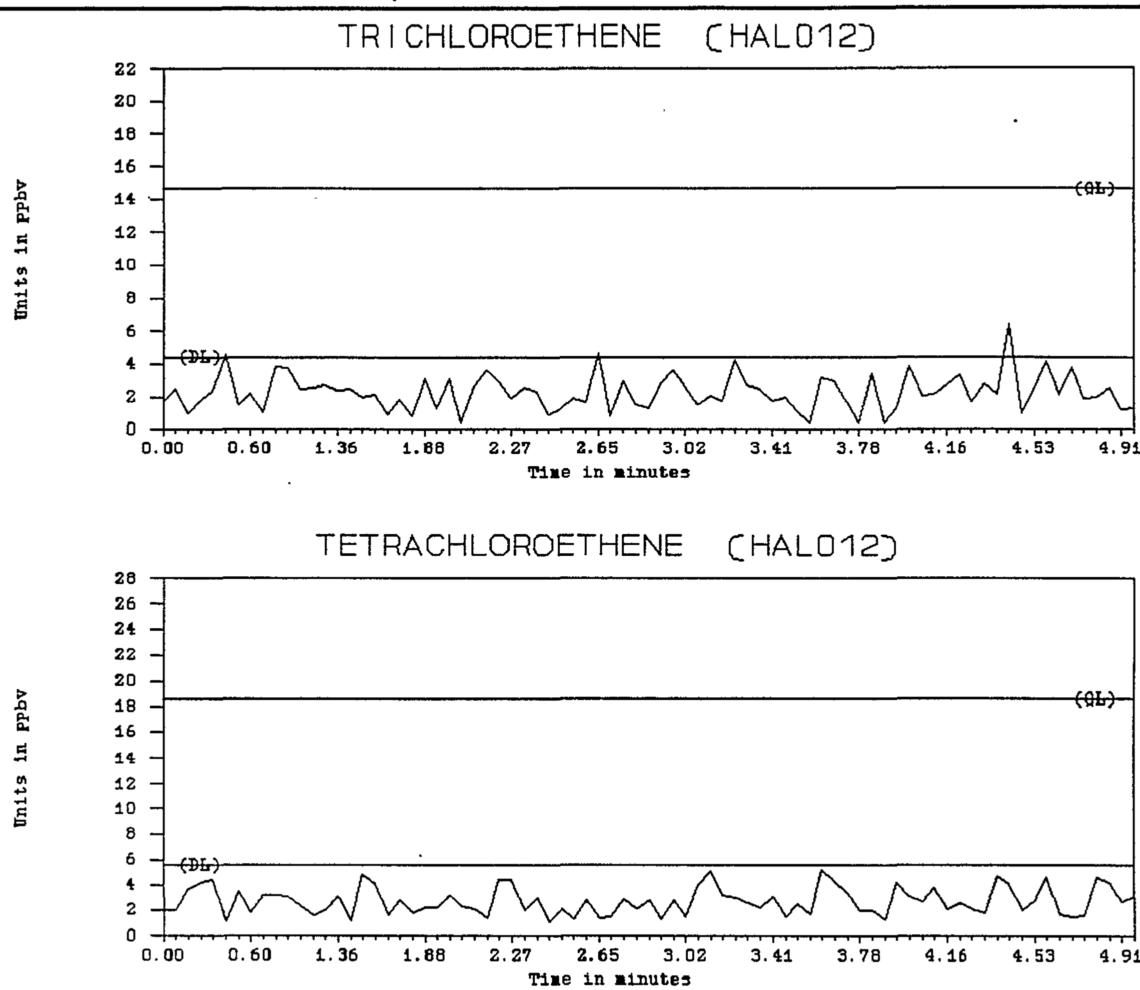

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FIGURE 8d
Background Subtracted Parent Ion Spectrum at Pit 2 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE

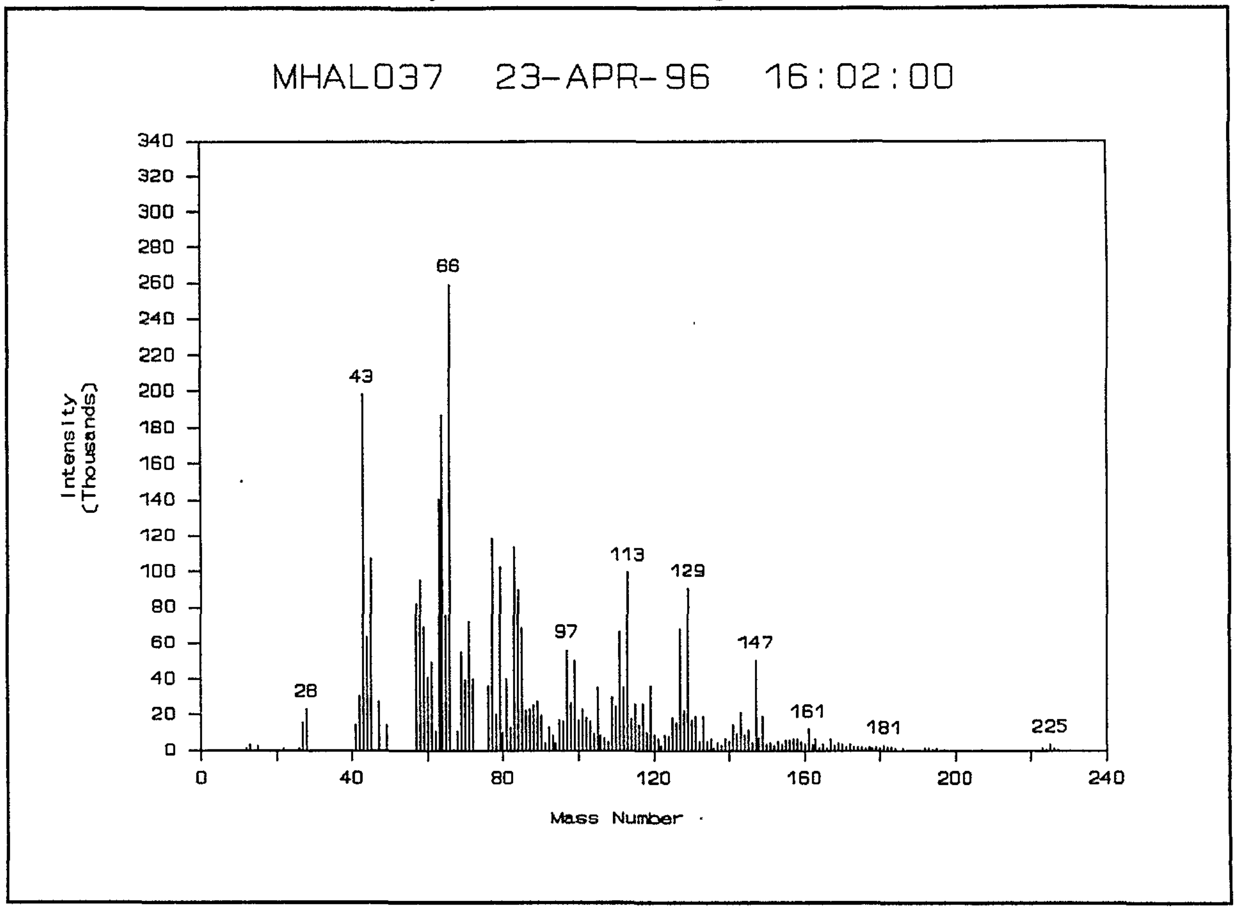

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FIGURE 8e
Daughter Ion Spectrum (m/z = 79) at Pit 2 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE

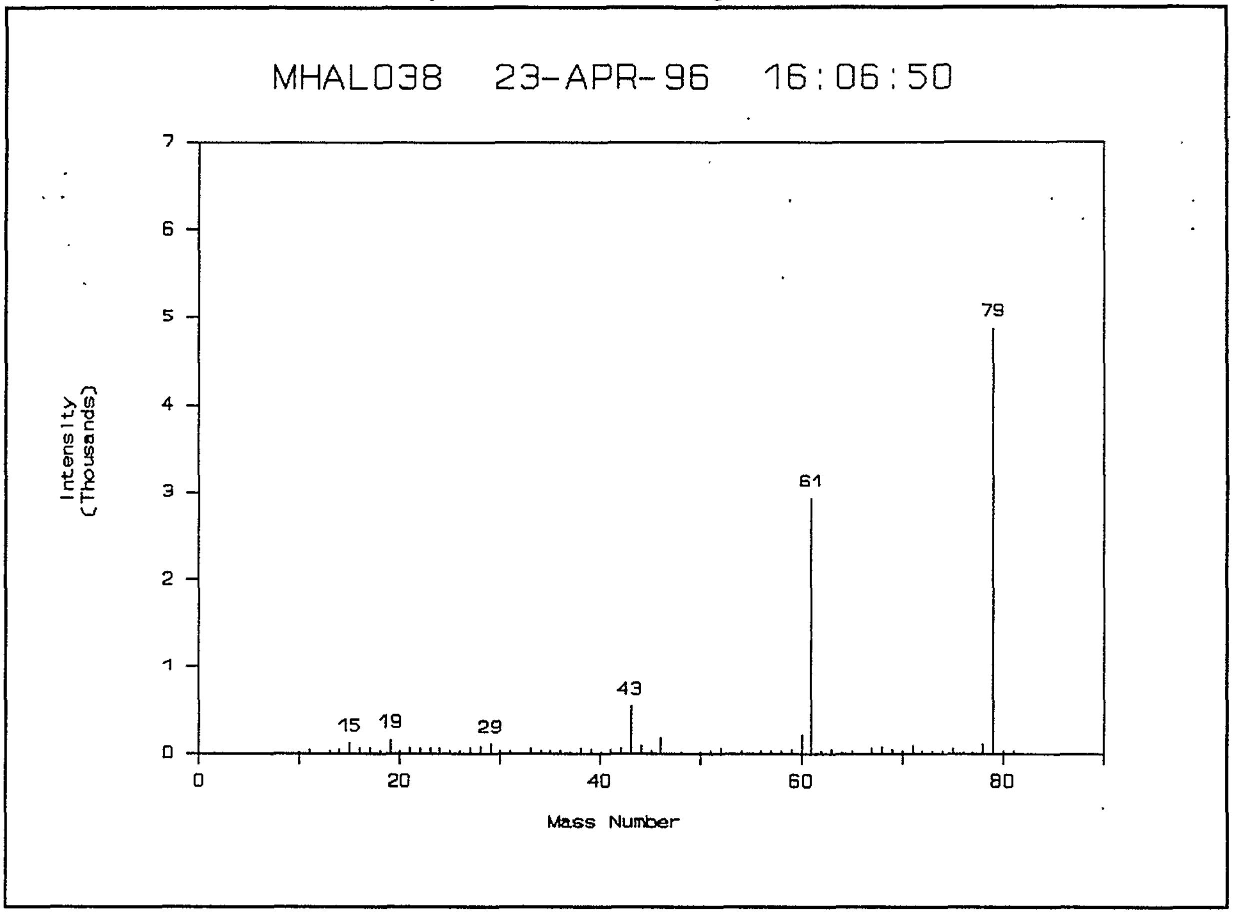

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FIGURE 8f
Daughter Ion Spectrum (m/z = 77) at Pit 2 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE

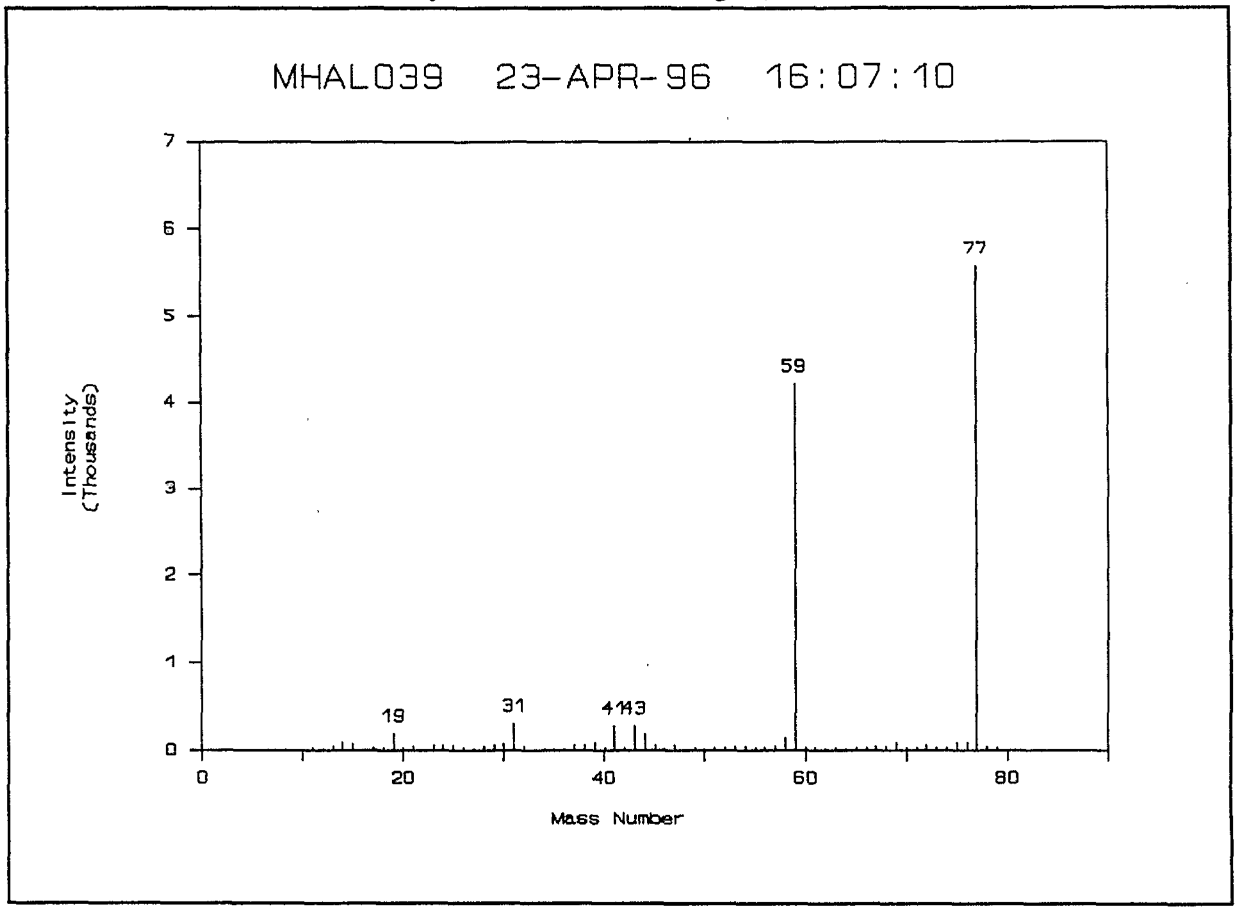

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FIGURE 8g
Daughter Ion Spectrum (m/z = 83) at Pit 2 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE

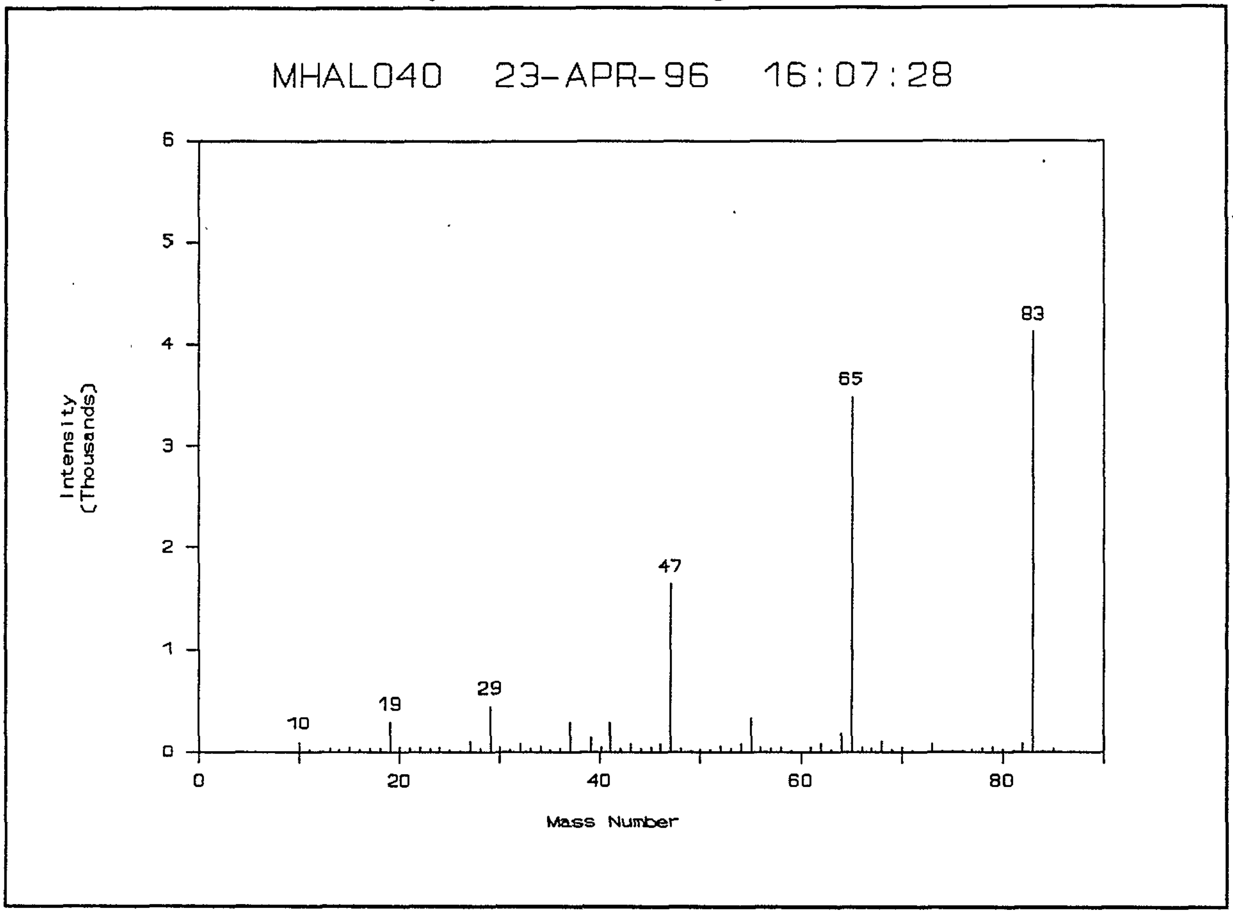

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FIGURE 8h
Daughter Ion Spectrum (m/z = 85) at Pit 2 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE

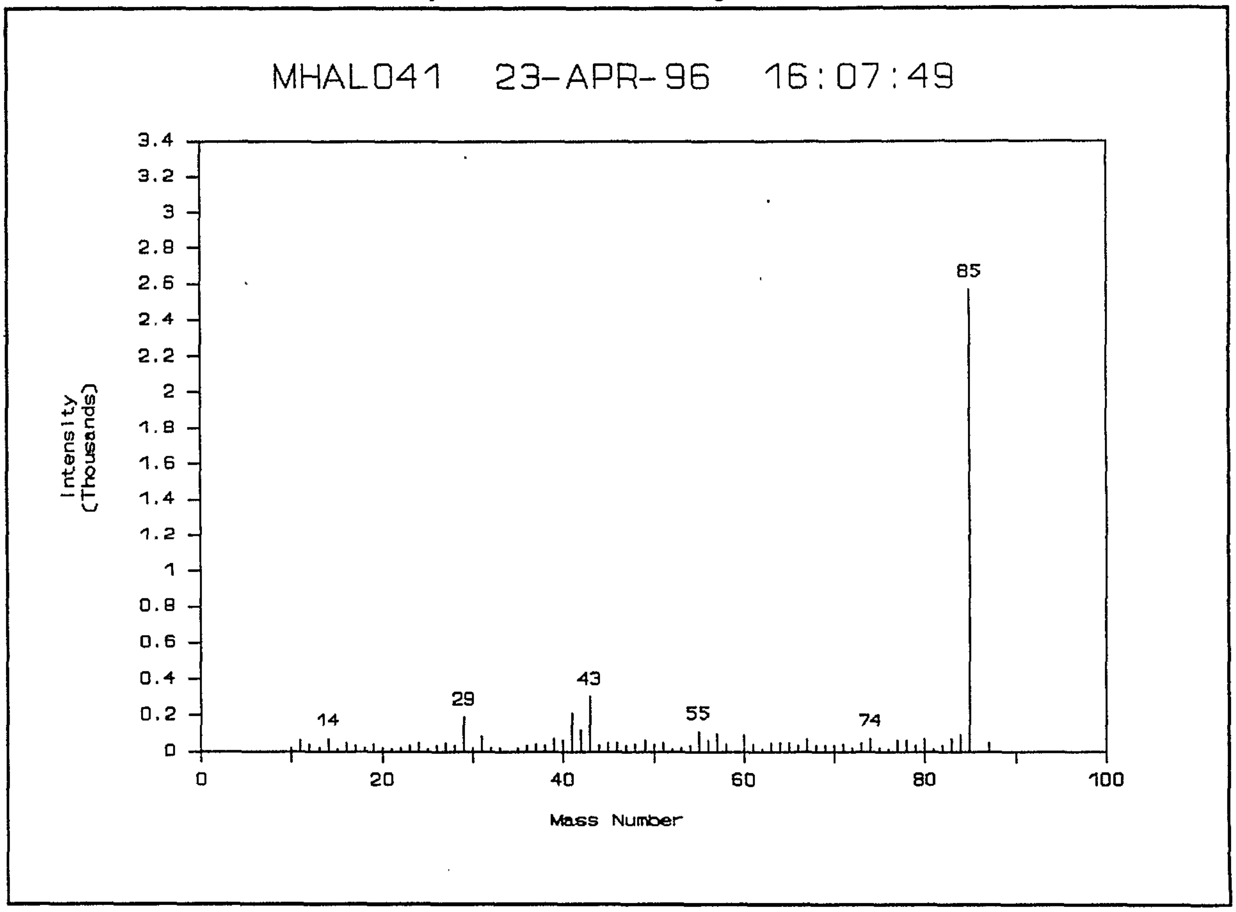

FIGURE 8i
Daughter Ion Spectrum (m/z = 113) at Pit 2 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE

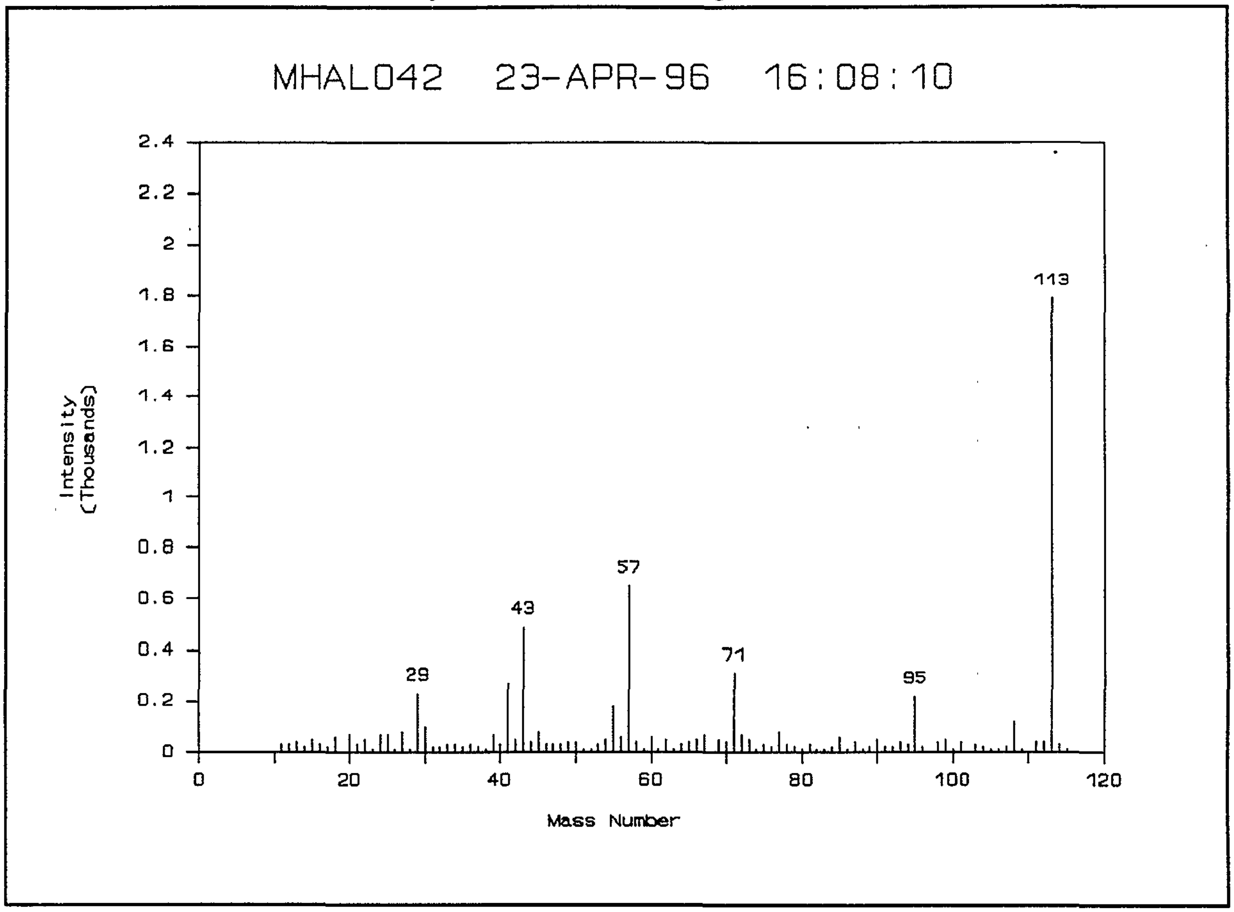

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FIGURE 8j
Daughter Ion Spectrum (m/z = 125) at Pit 2 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE

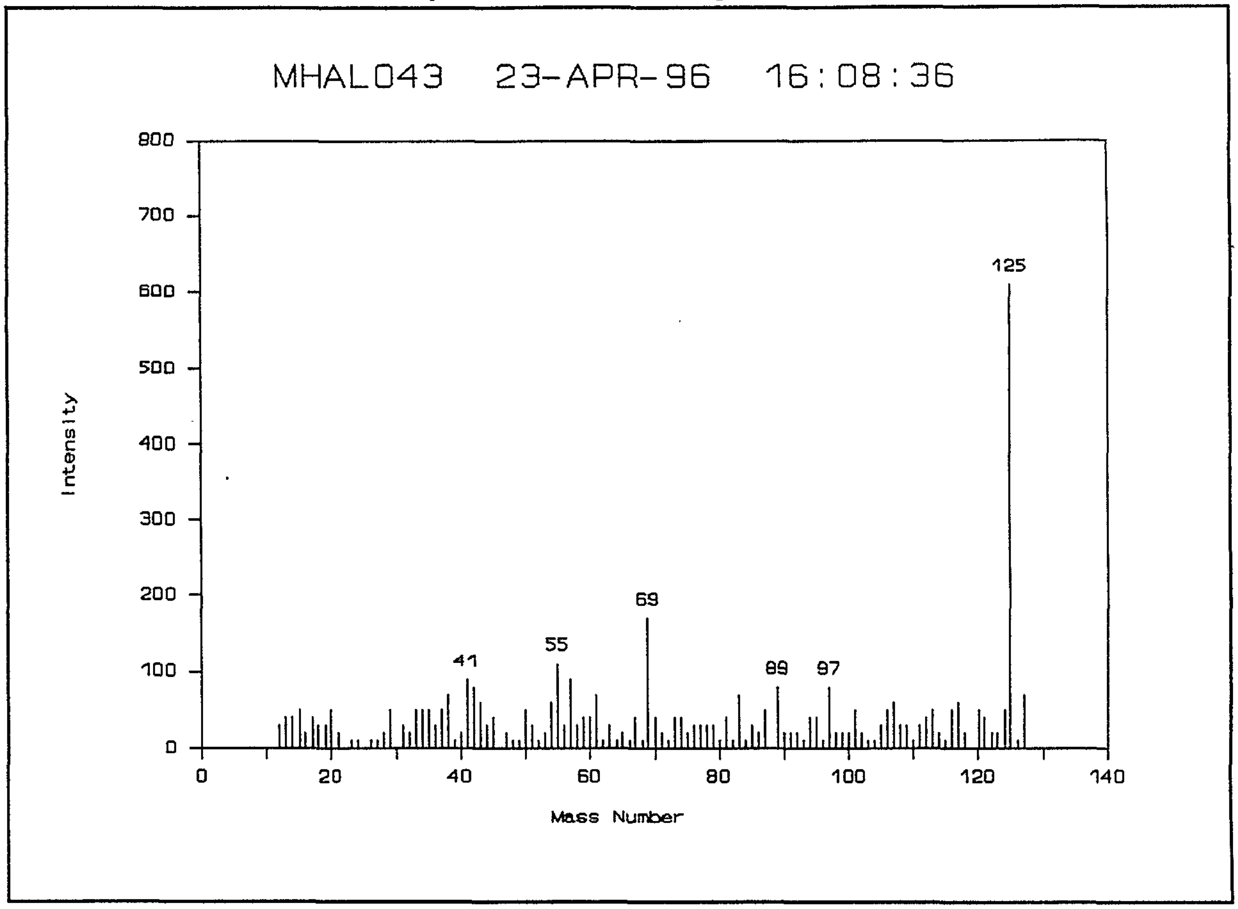

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FIGURE 8k
Daughter Ion Spectrum (m/z = 127) at Pit 2 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE

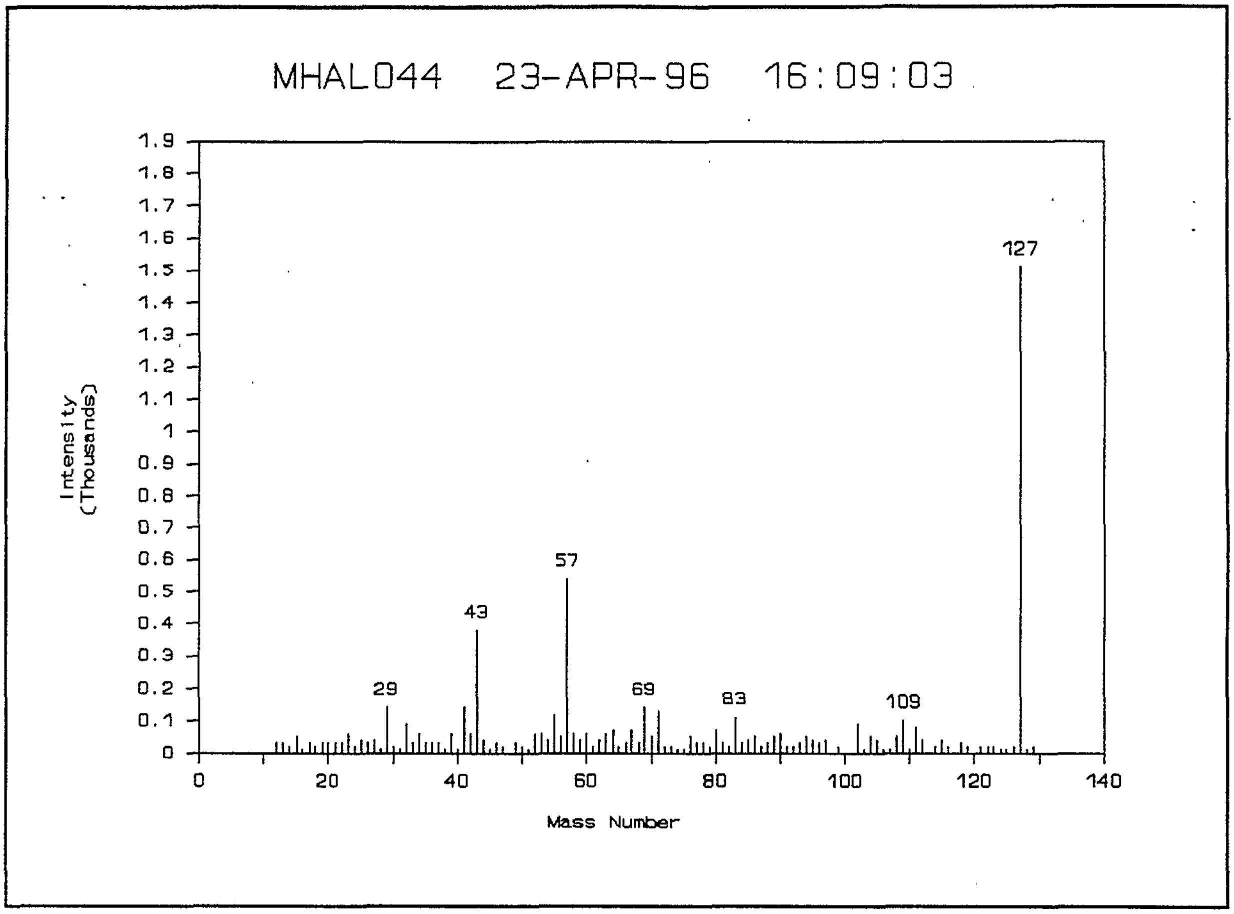

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FIGURE 81
Daughter Ion Spectrum (m/z = 129) at Pit 2 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE

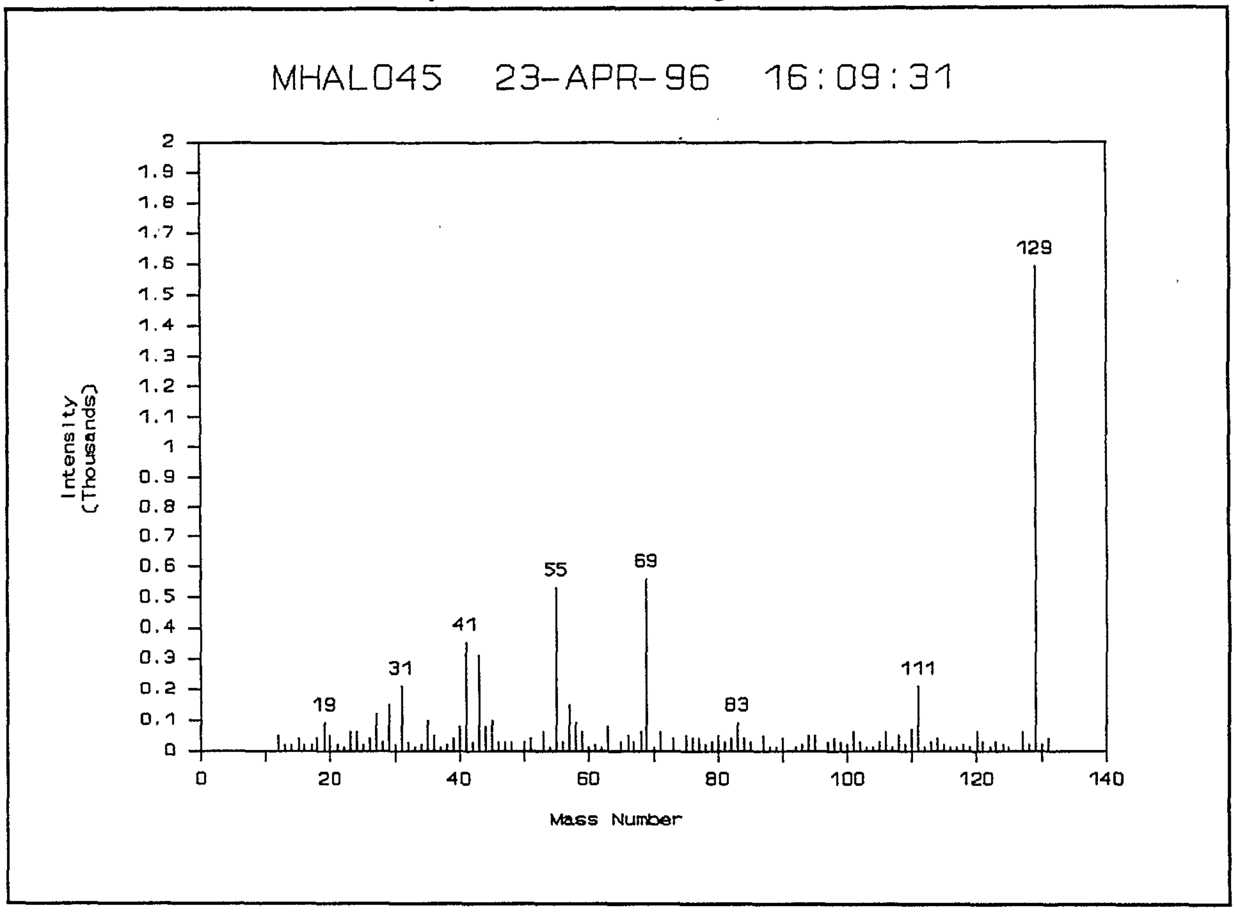

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FIGURE 8m
Daughter Ion Spectrum (m/z = 147) at Pit 2 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE

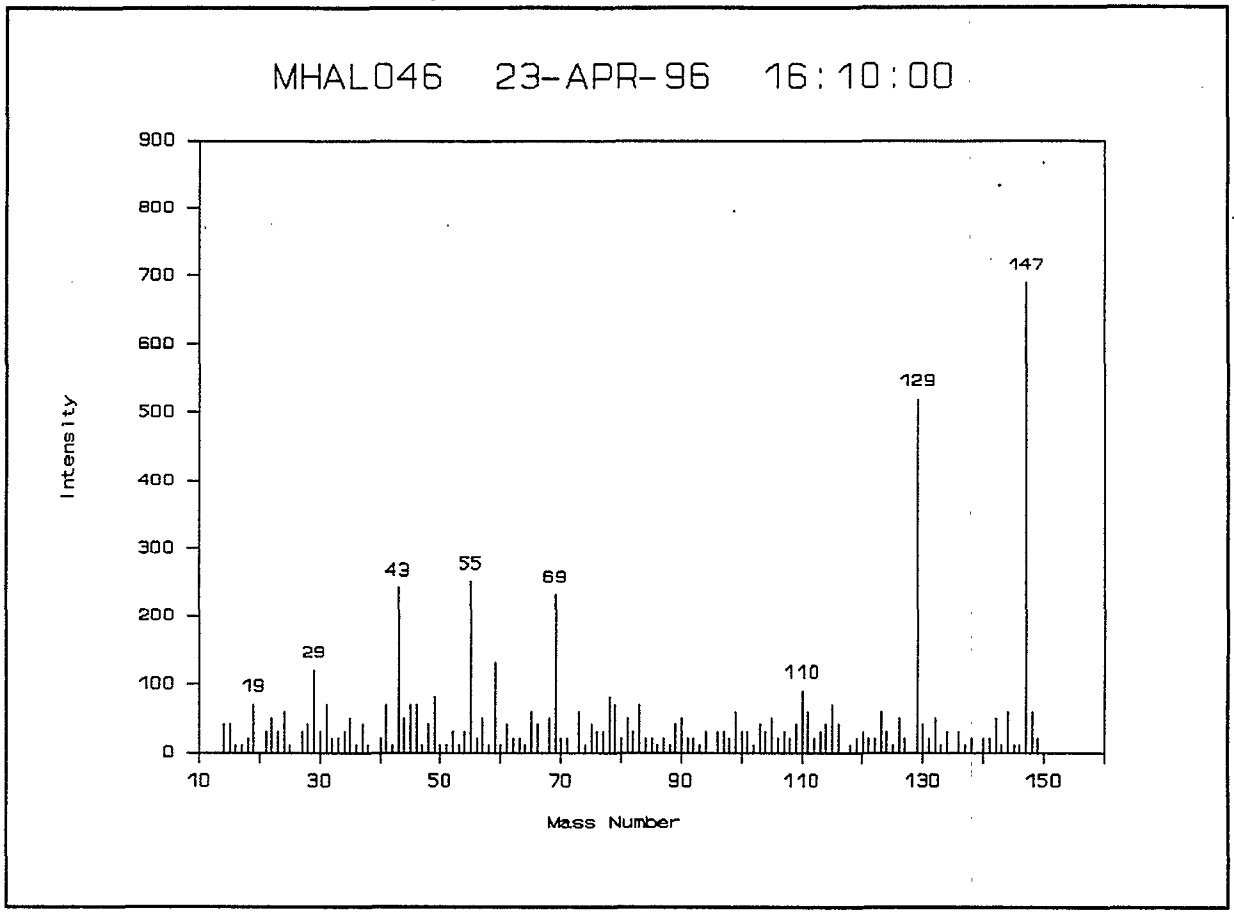

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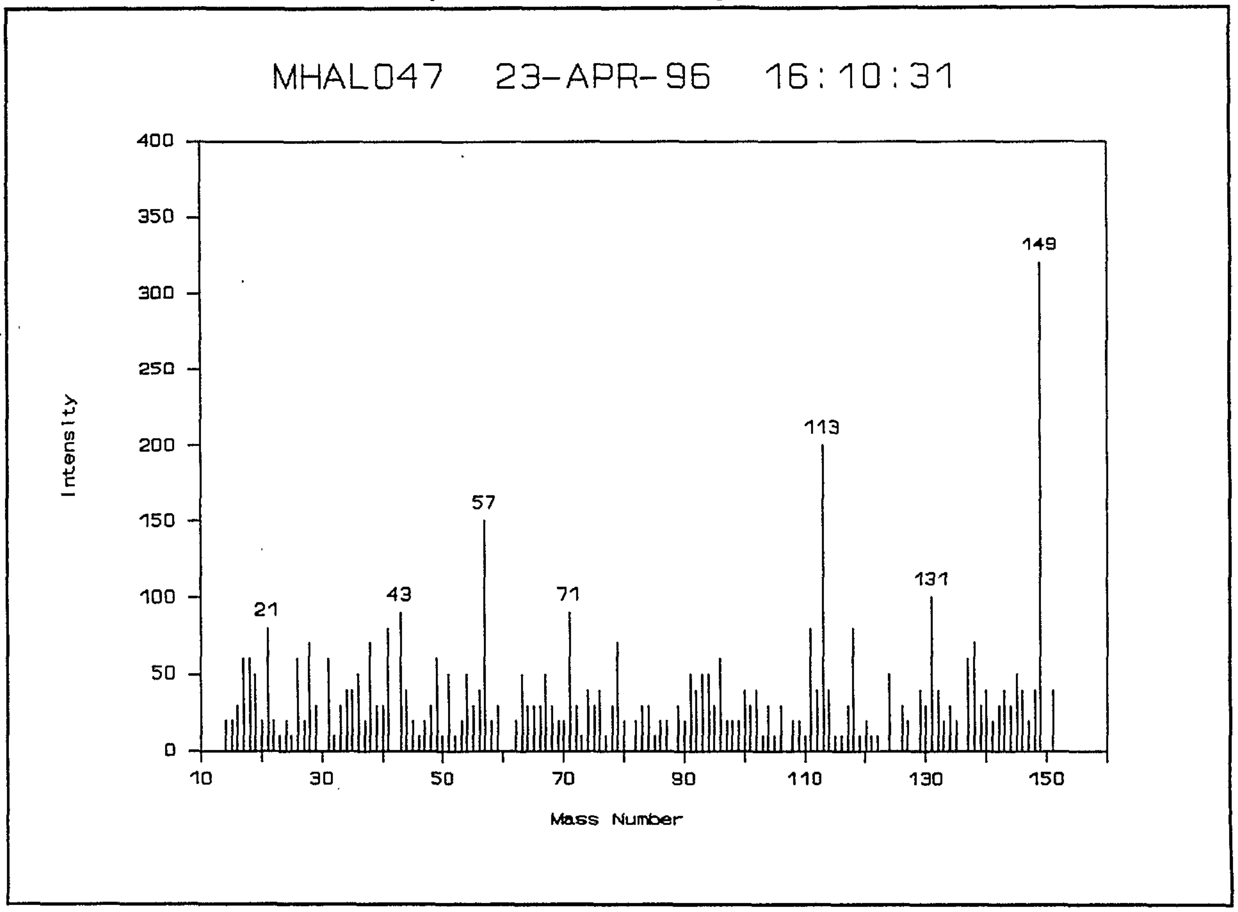
FIGURE 8n
Daughter Ion Spectrum (m/z = 149) at Pit 2 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE



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Pit 3 Extension - Hose in the Pit

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FIGURE 9a
Stationary Monitoring at Pit 3 Extension - Hose in the Pit
for Vinyl Chloride, Benzene, and Ethylisothiocyanate
Halby Chemical Site, Wilmington, DE

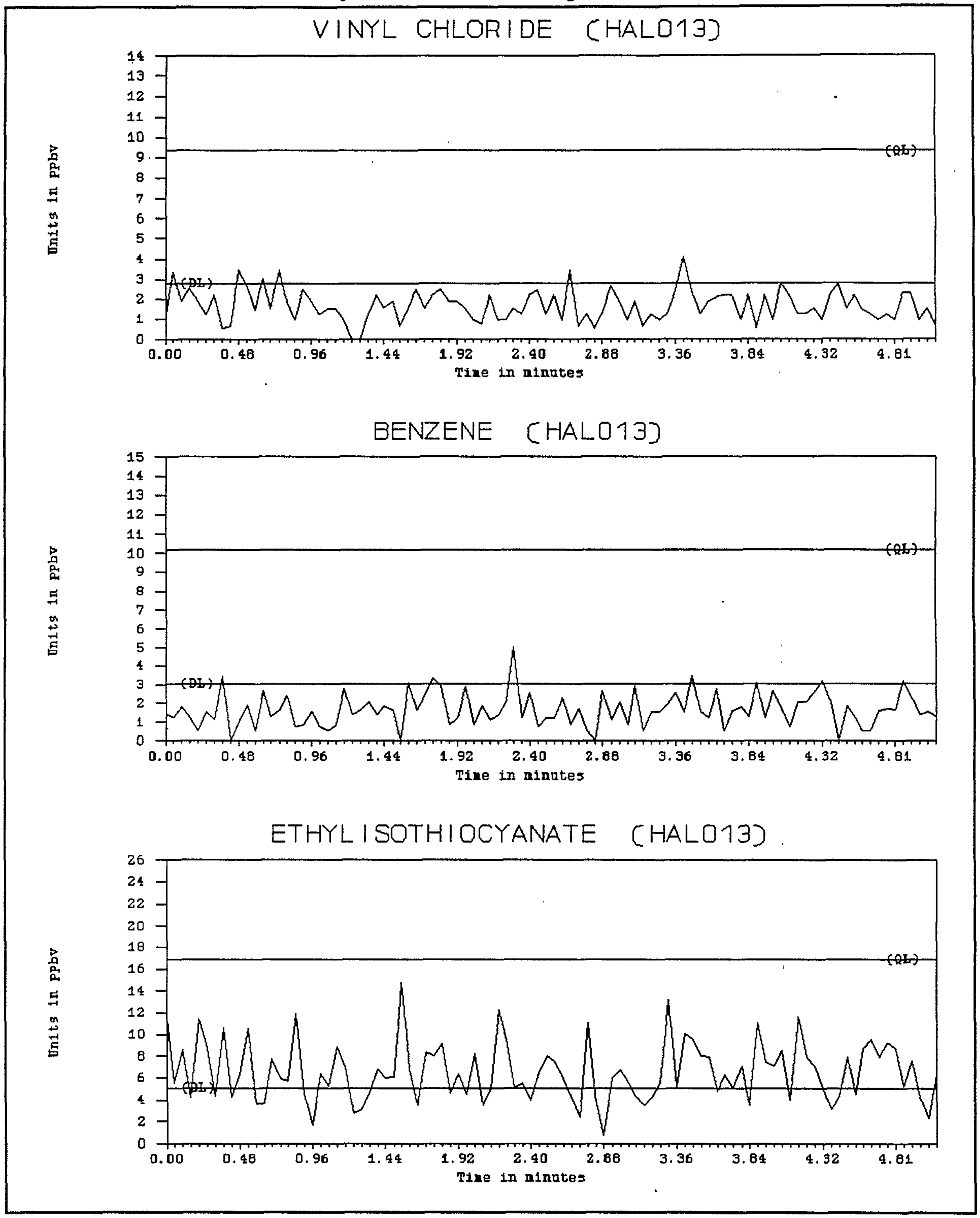

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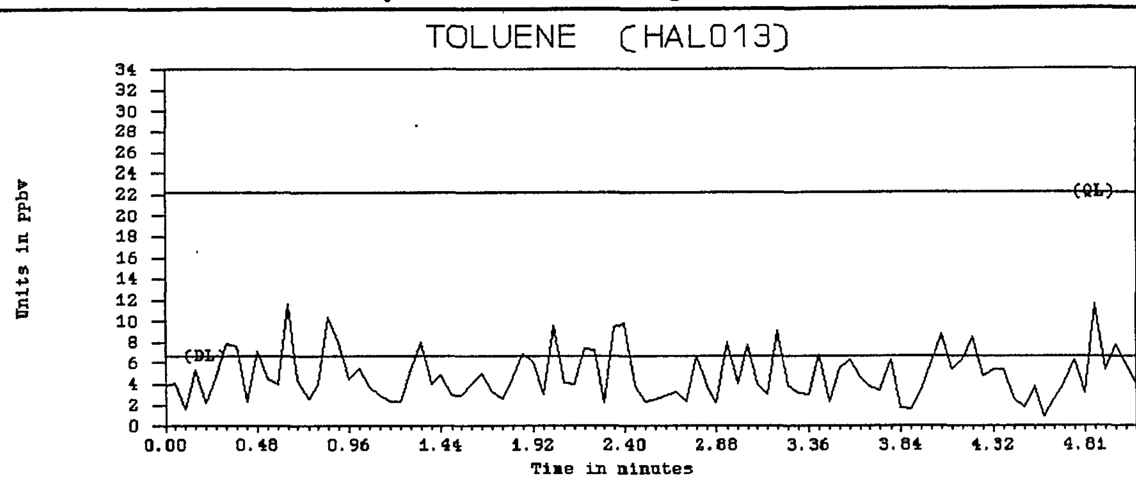
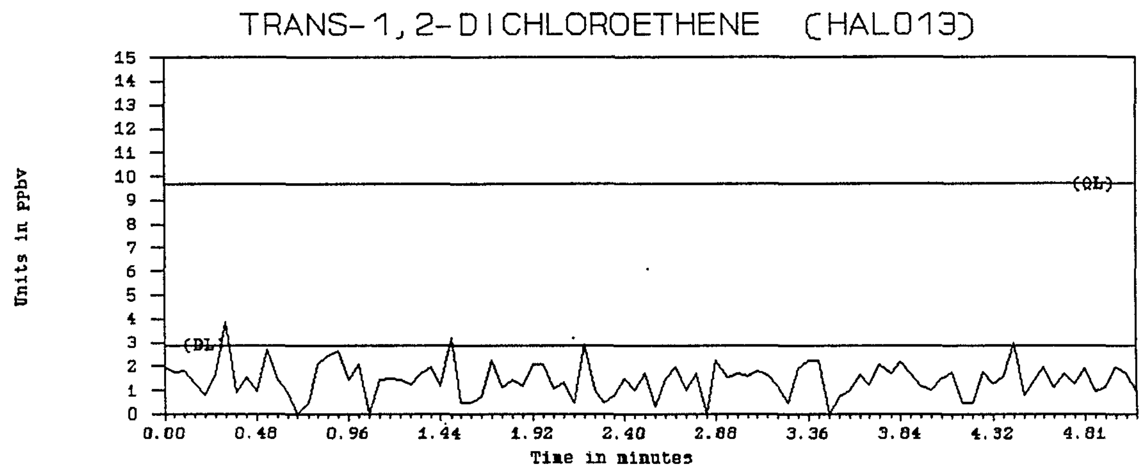
FIGURE 9b

Stationary Monitoring at Pit 3 Extension - Hose in the Pit for Toluene, Trans-1,2-Dichloroethene, and Xylene Halby Chemical Site, Wilmington, DE





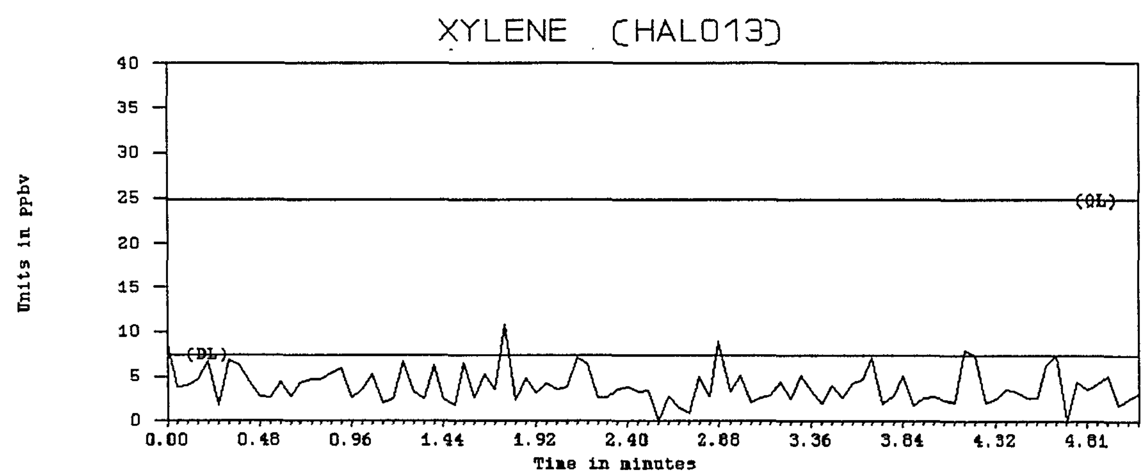


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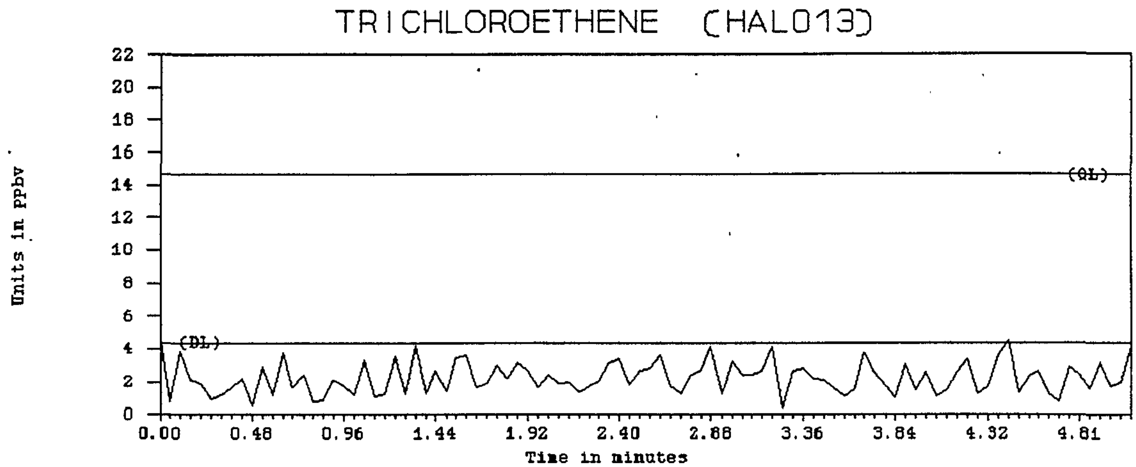
FIGURE 9c
Stationary Monitoring at Pit 3 Extension - Hose in the Pit
for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE



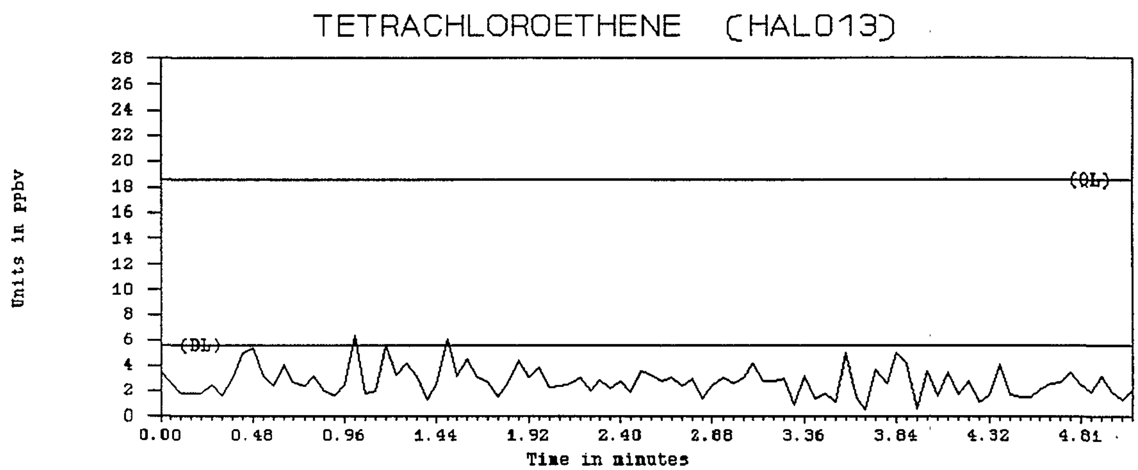


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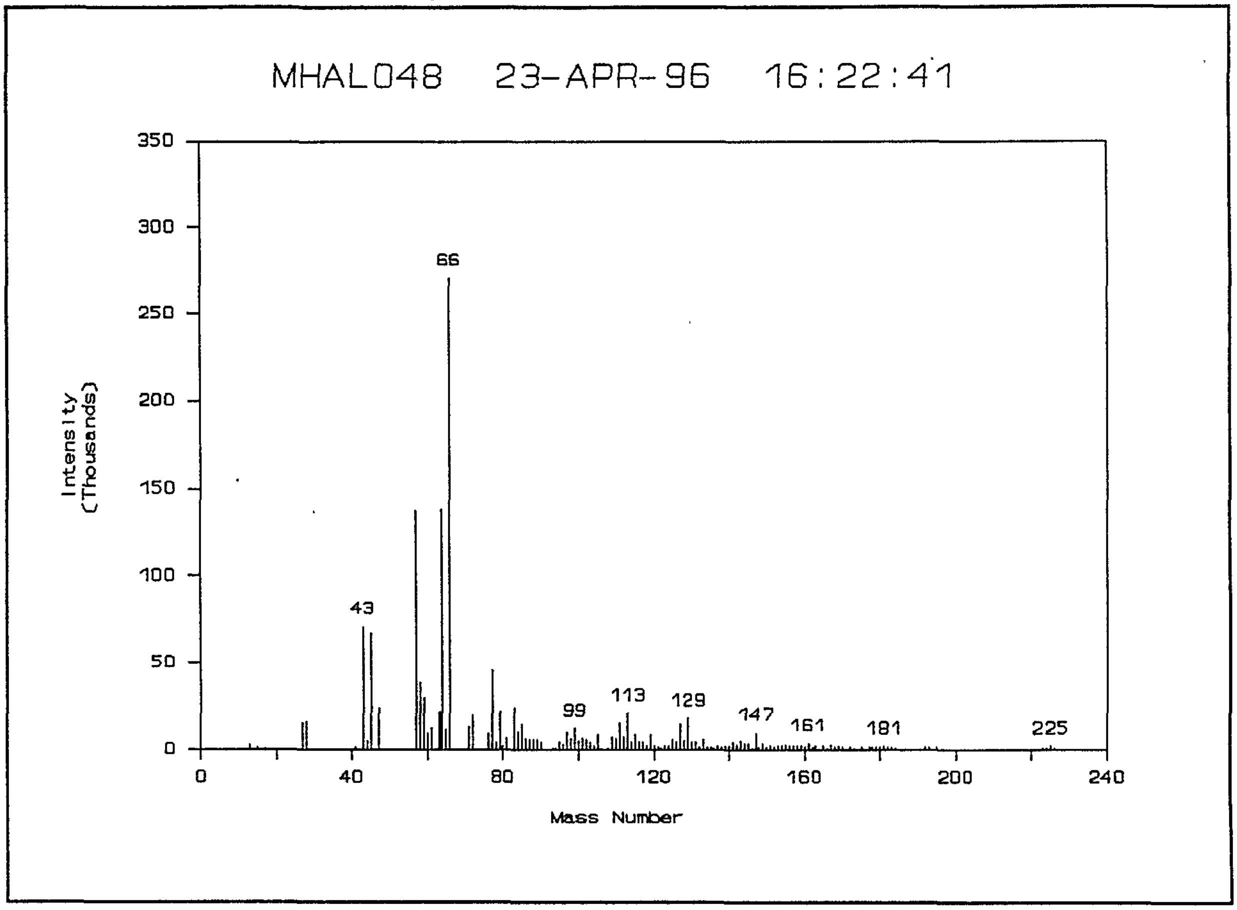
FIGURE 9d
Background Subtracted Parent Ion Spectrum at Pit 3 Extension - Hose in Pit
Halby Chemical Site, Wilmington, DE



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Pit 4 - Hose in the Pit

FIGURE 10a
Stationary Monitoring at Pit 4 - Hose in the Pit
for Vinyl Chloride, Benzene, and Ethylisothiocyanate
Halby Chemical Site, Wilmington, DE

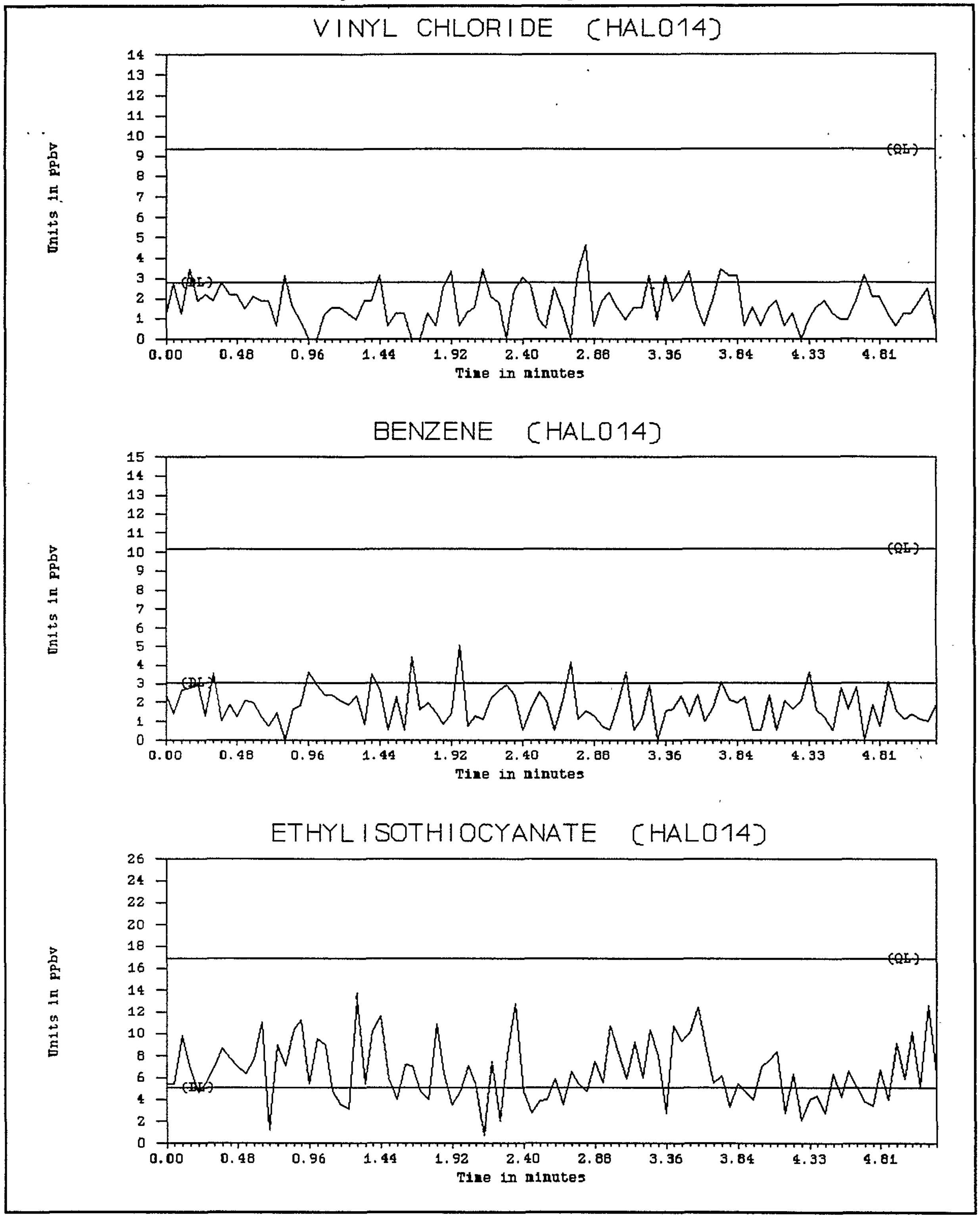

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FIGURE 10b
Stationary Monitoring at Pit 4 - Hose in the Pit
for Toluene, Trans-1,2-Dichloroethene, and Xylene
Halby Chemical Site, Wilmington, DE

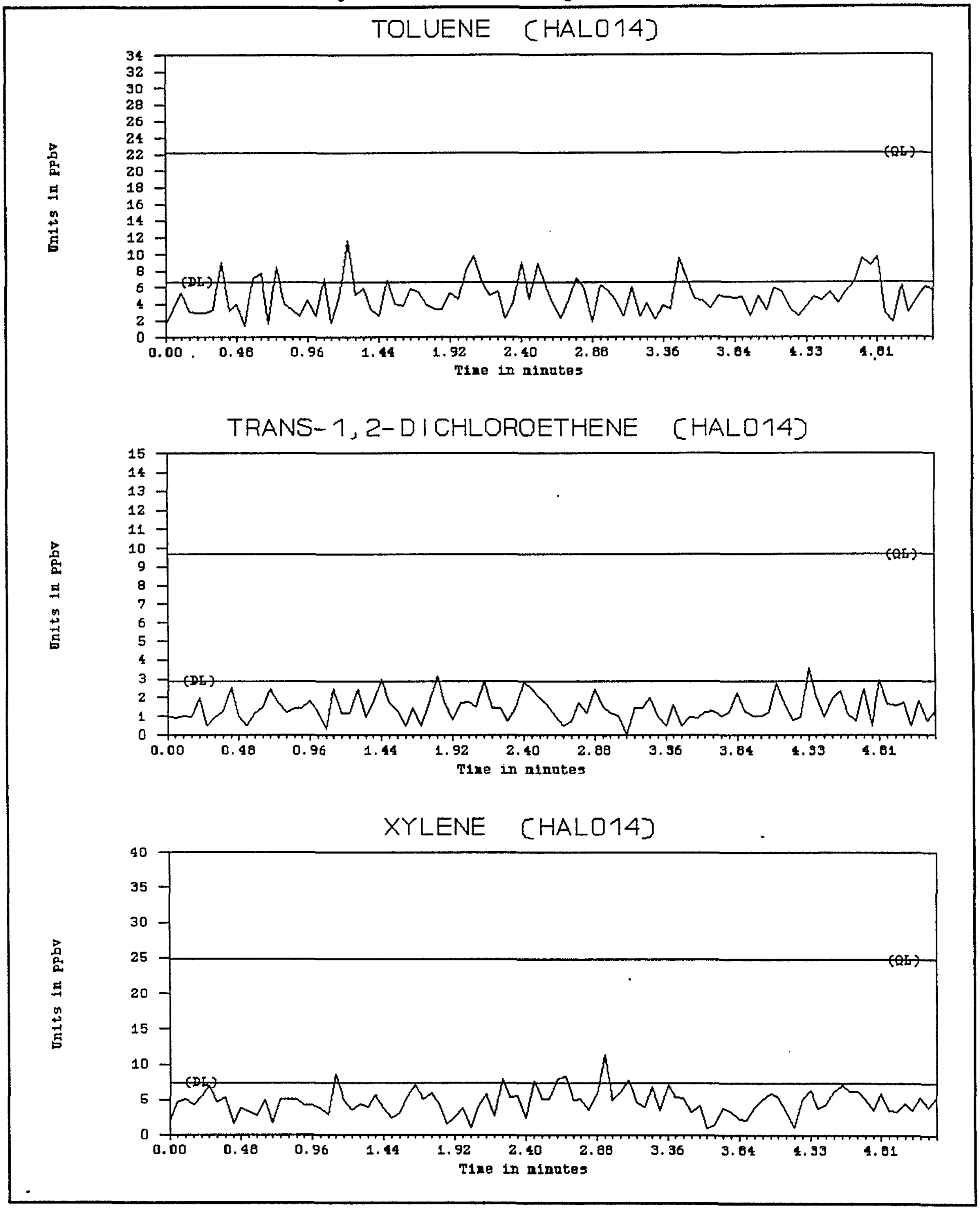

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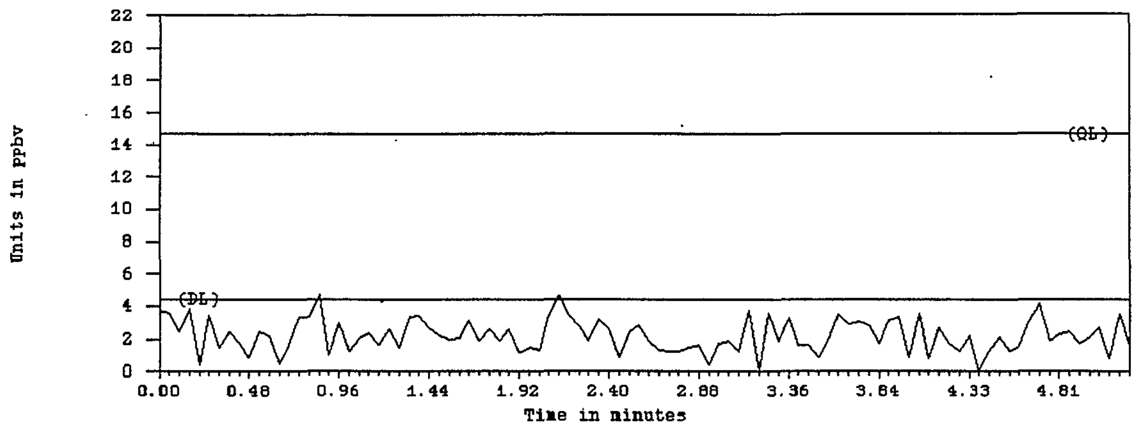
FIGURE 10c
Stationary Monitoring at Pit 4 - Hose in the Pit
for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE

TRICHLOROETHENE (HAL014)



TETRACHLOROETHENE (HAL014)

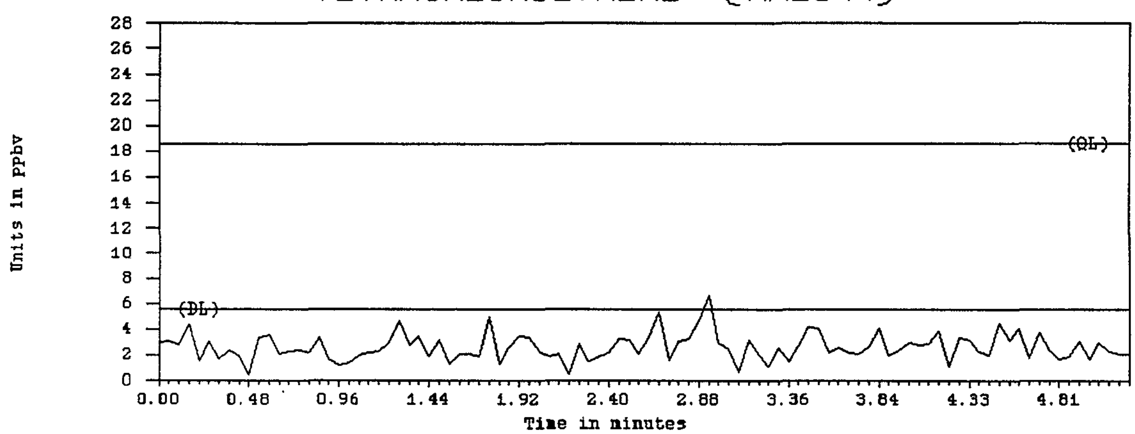


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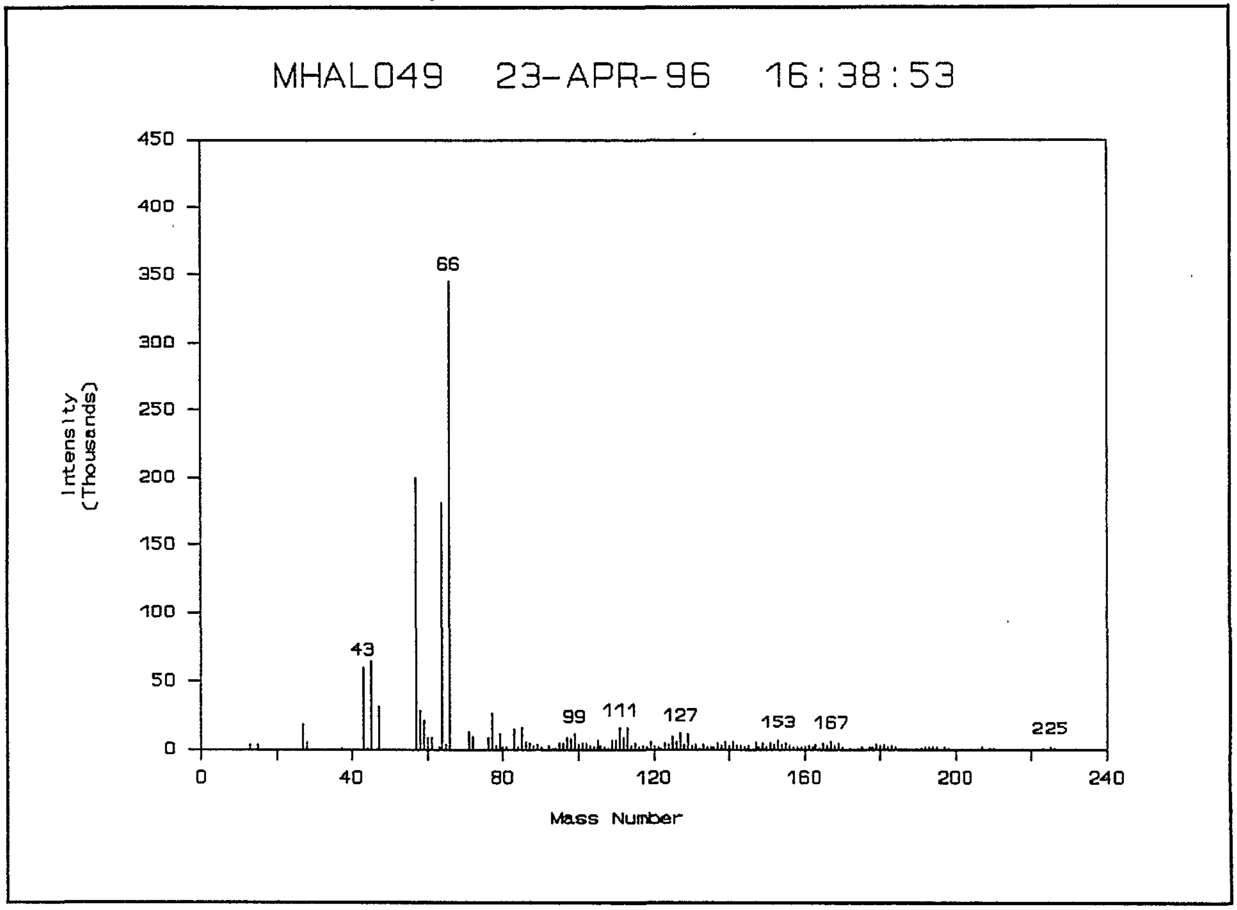
FIGURE 10d
Background Subtracted Parent Ion Spectrum at Pit 4 - Hose in Pit
Halby Chemical Site, Wilmington, DE



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Enlarged Pit 1 - Hose in the Pit

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FIGURE 11a
Stationary Monitoring at Enlarged Pit 1 - Hose in the Pit for Vinyl Chloride, Benzene, and Ethylisothiocyanate Halby Chemical Site, Wilmington, DE

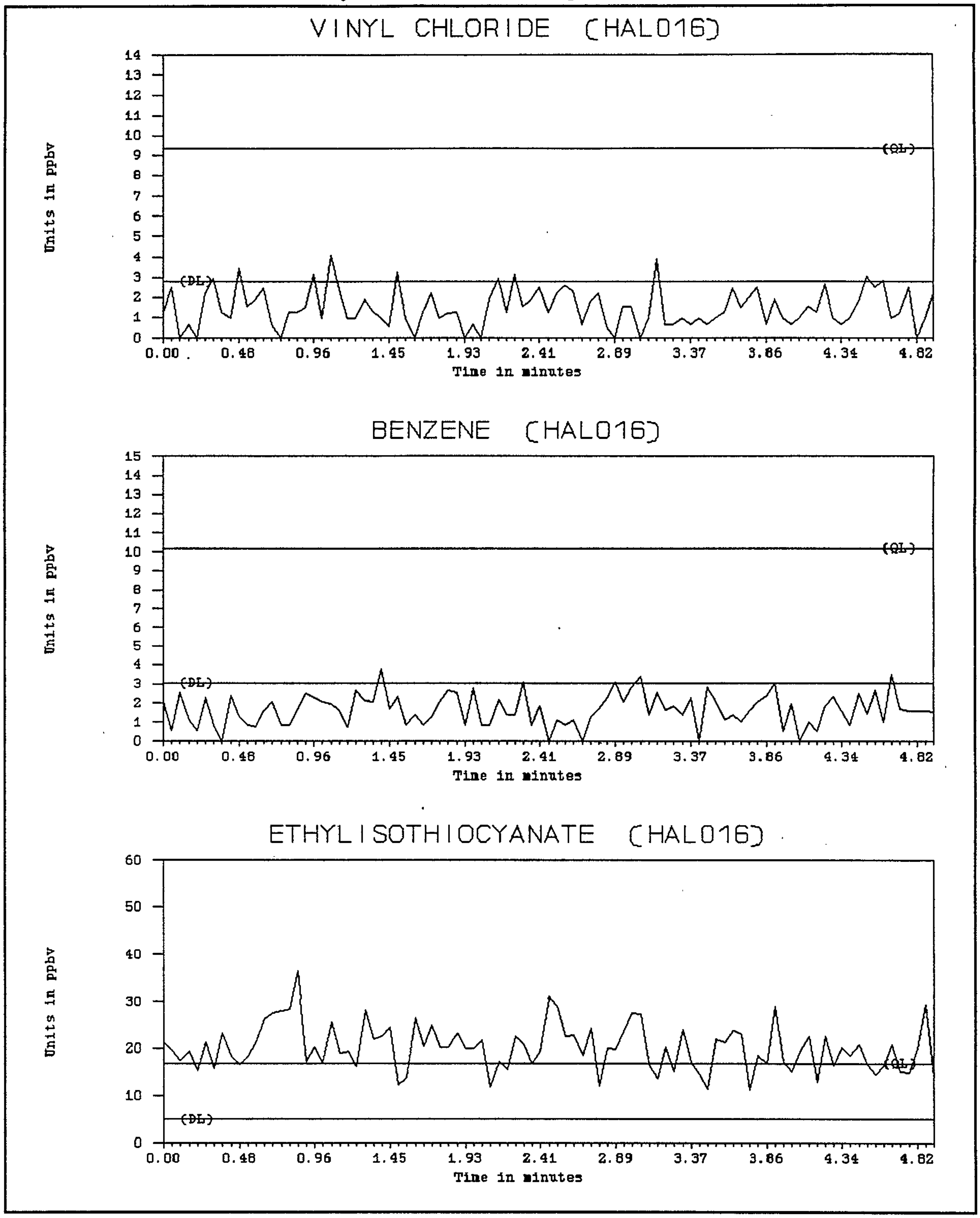

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FIGURE 11b
Stationary Monitoring at Enlarged Pit 1 - Hose in the Pit
for Toluene, Trans-1,2-Dichloroethene, and Xylene
Halby Chemical Site, Wilmington, DE

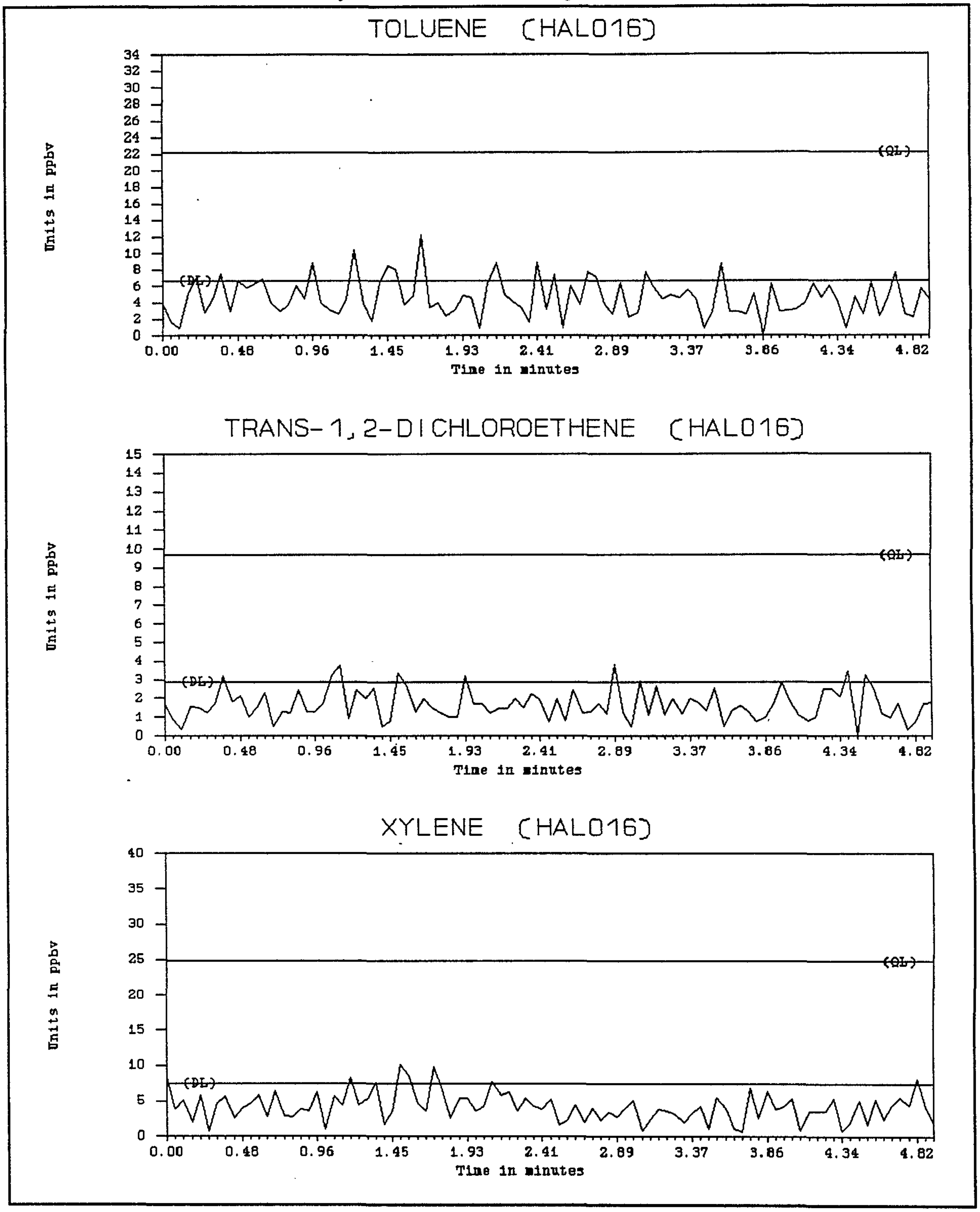

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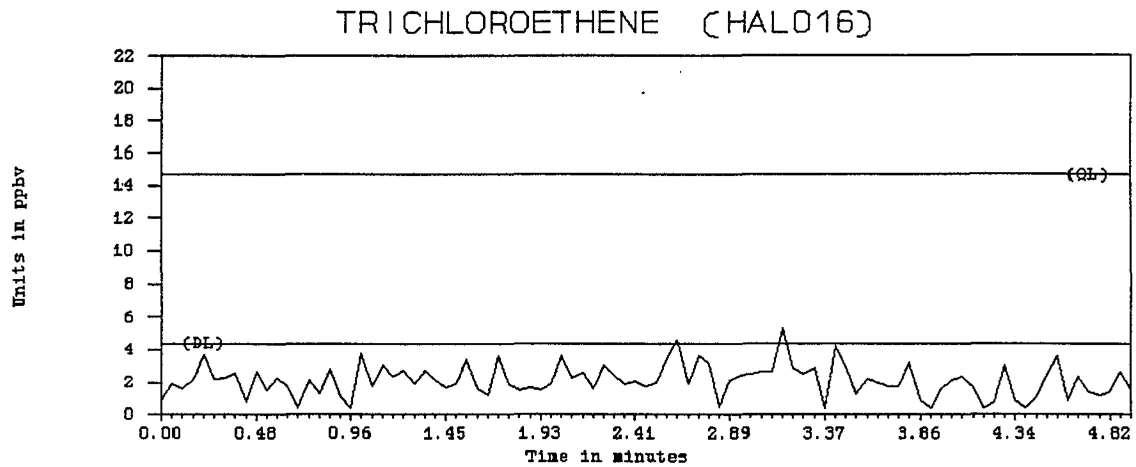
FIGURE 11c
Stationary Monitoring at Enlarged Pit 1 - Hose in the Pit
for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE



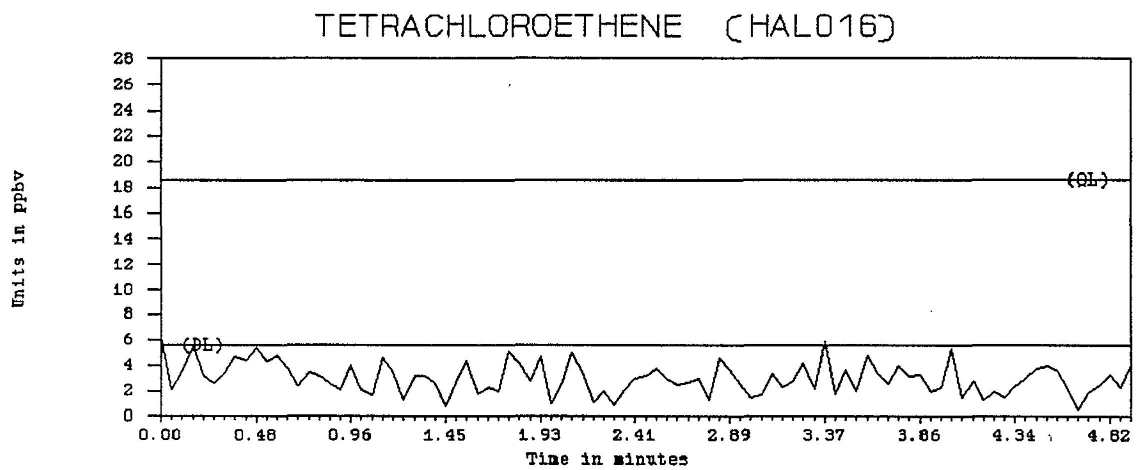


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FIGURE 11d
Background Subtracted Parent Ion Spectrum at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

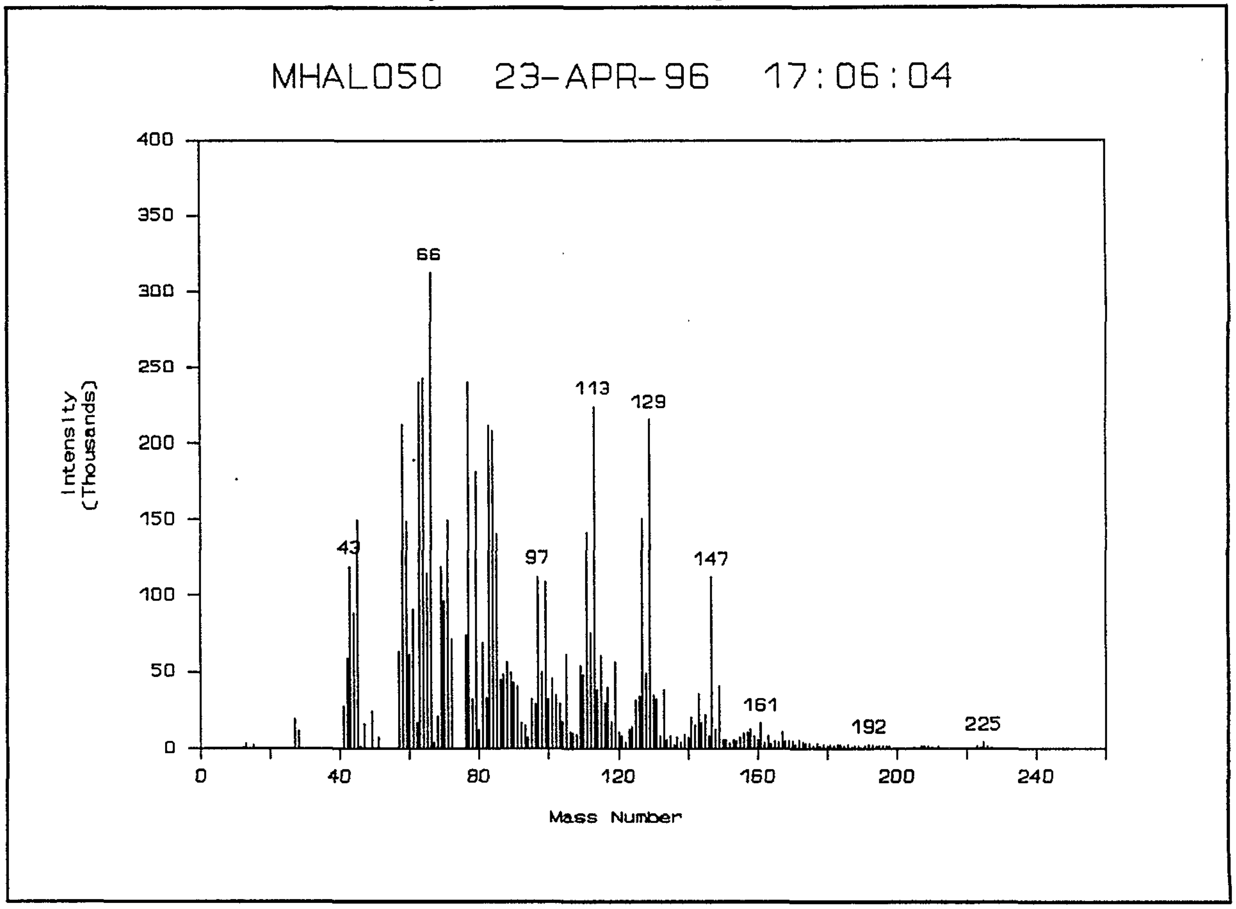

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FIGURE 11e
Daughter Ion Spectrum (m/z = 77) at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

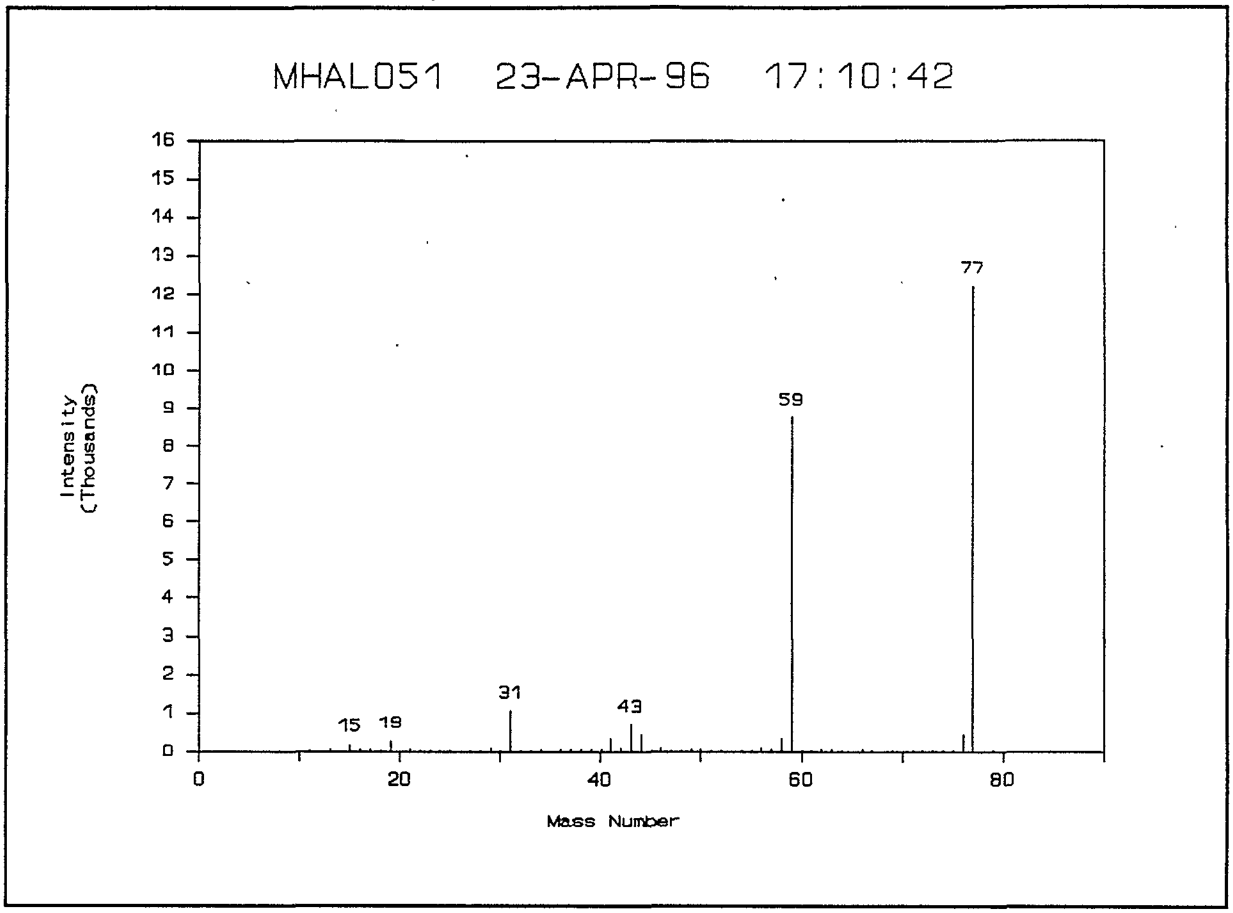

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FIGURE 11f
Daughter Ion Spectrum (m/z = 79) at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

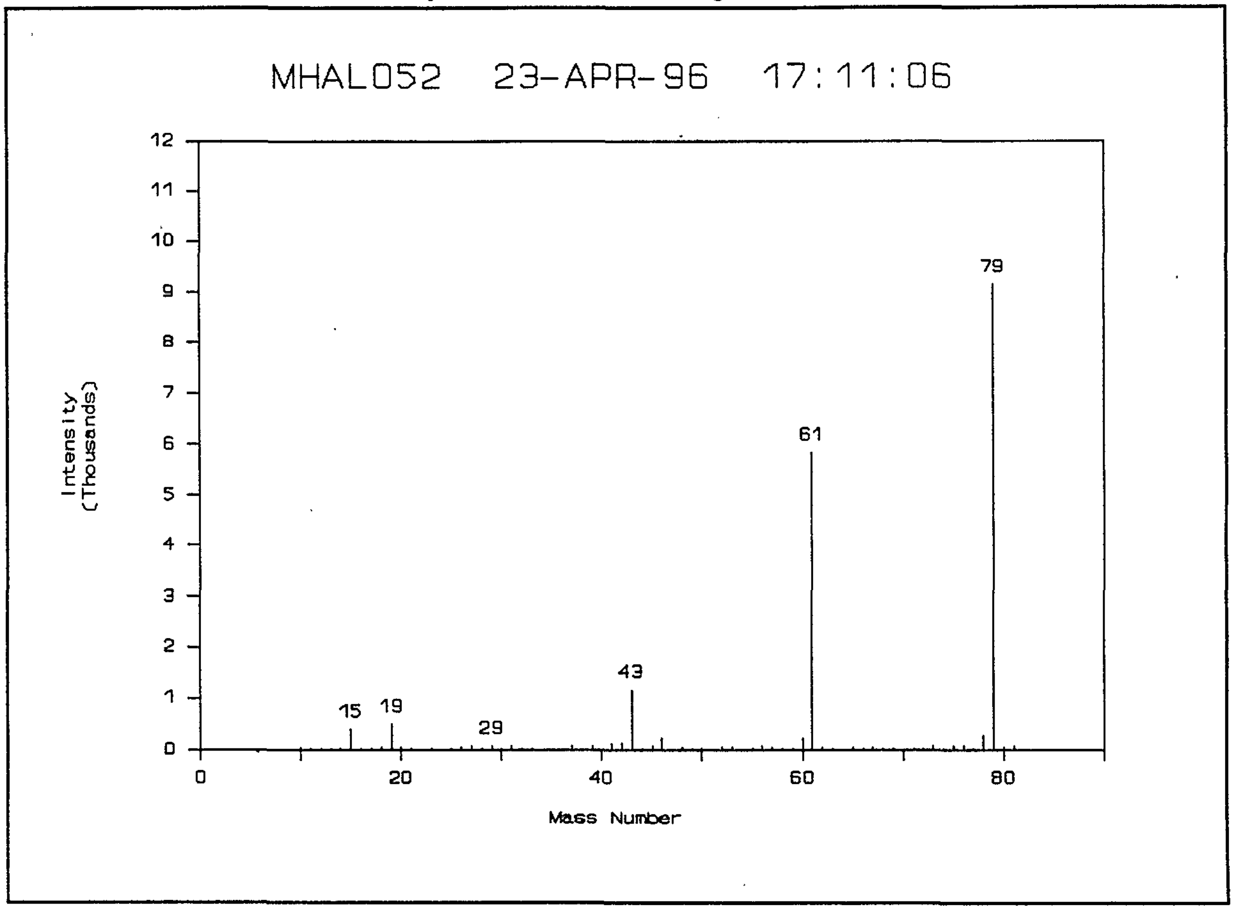

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FIGURE 11g
Daughter Ion Spectrum (m/z = 83) at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

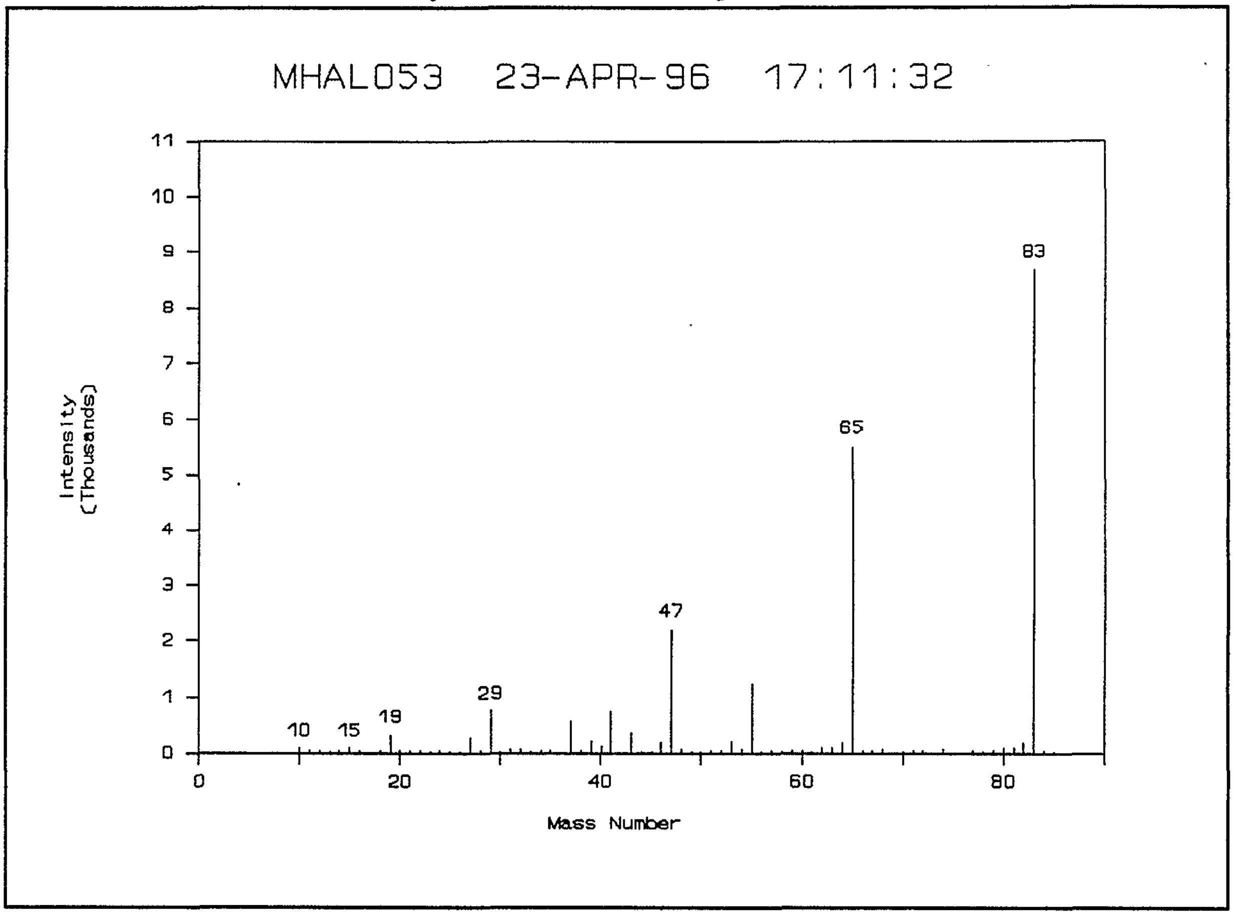

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FIGURE 11h
Daughter Ion Spectrum (m/z = 85) at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

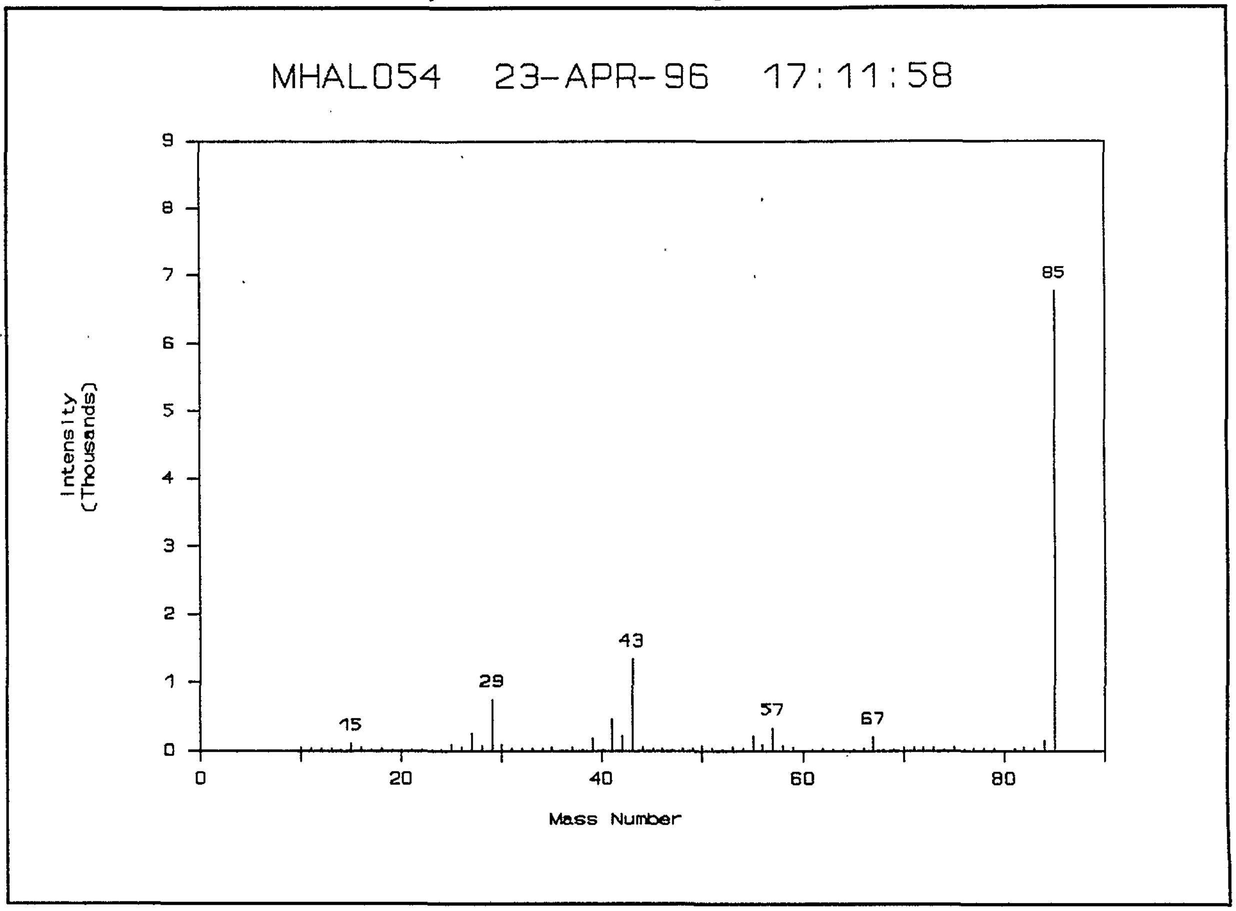

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FIGURE 11i
Daughter Ion Spectrum (m/z = 97) at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

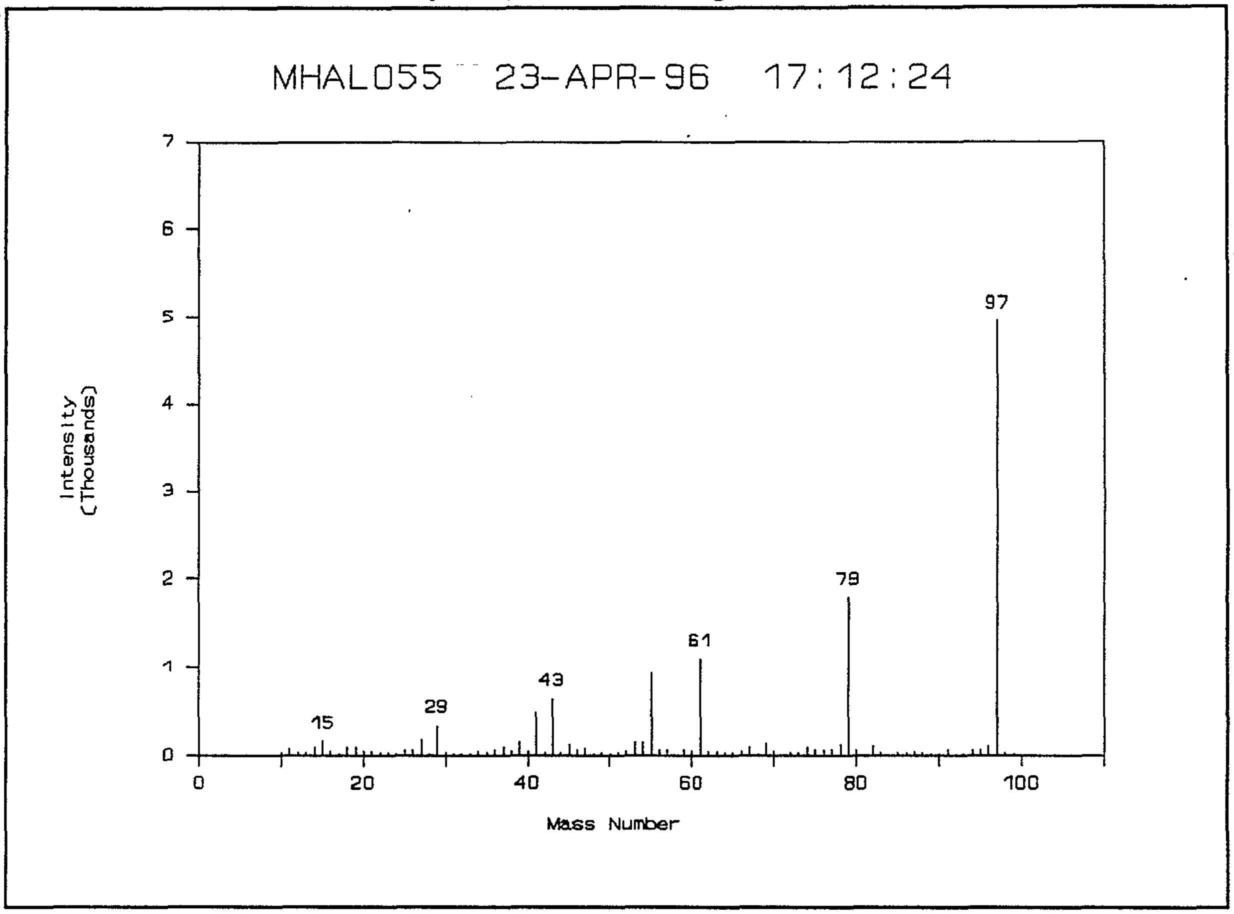

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FIGURE 11j
Daughter Ion Spectrum (m/z = 99) at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

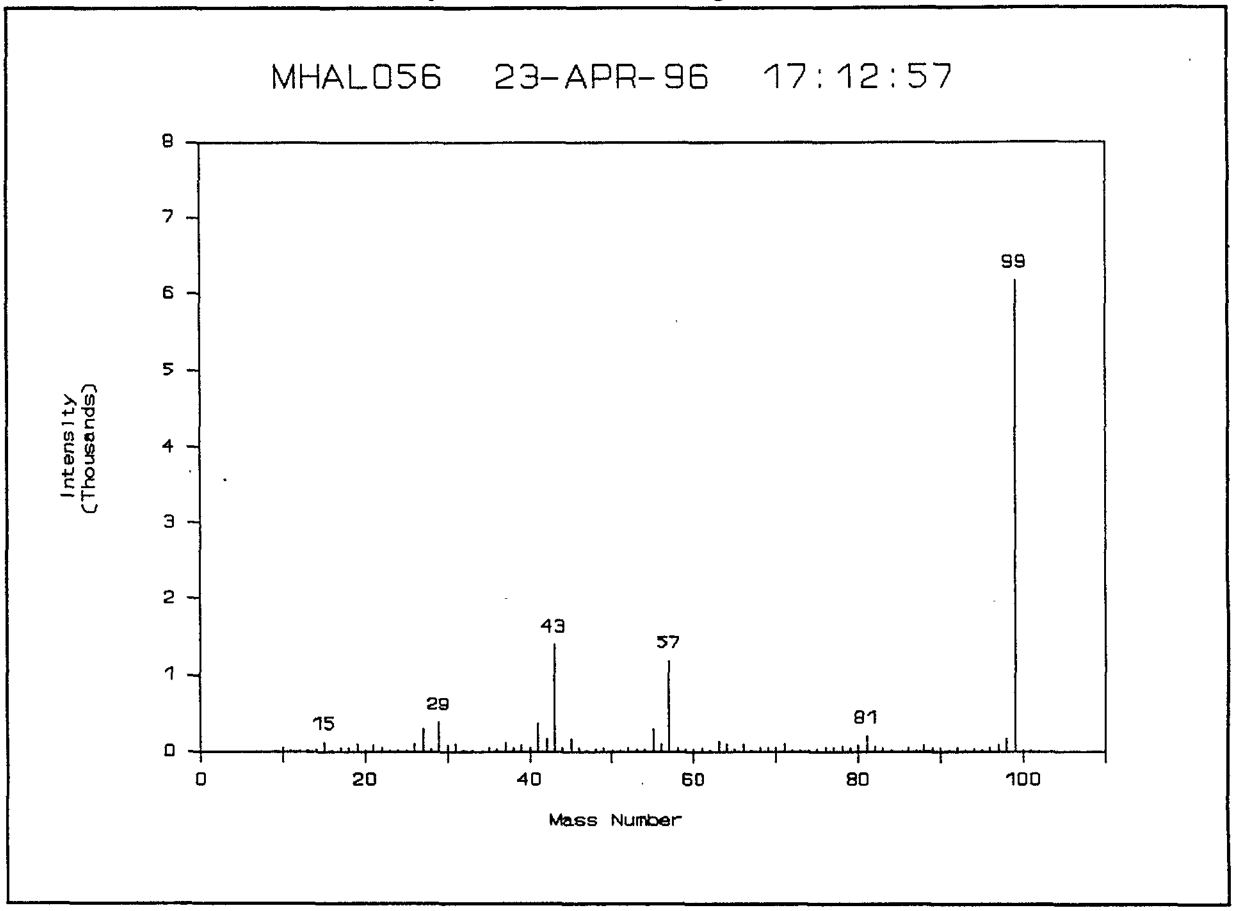

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FIGURE 11k
Daughter Ion Spectrum (m/z = 111) at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

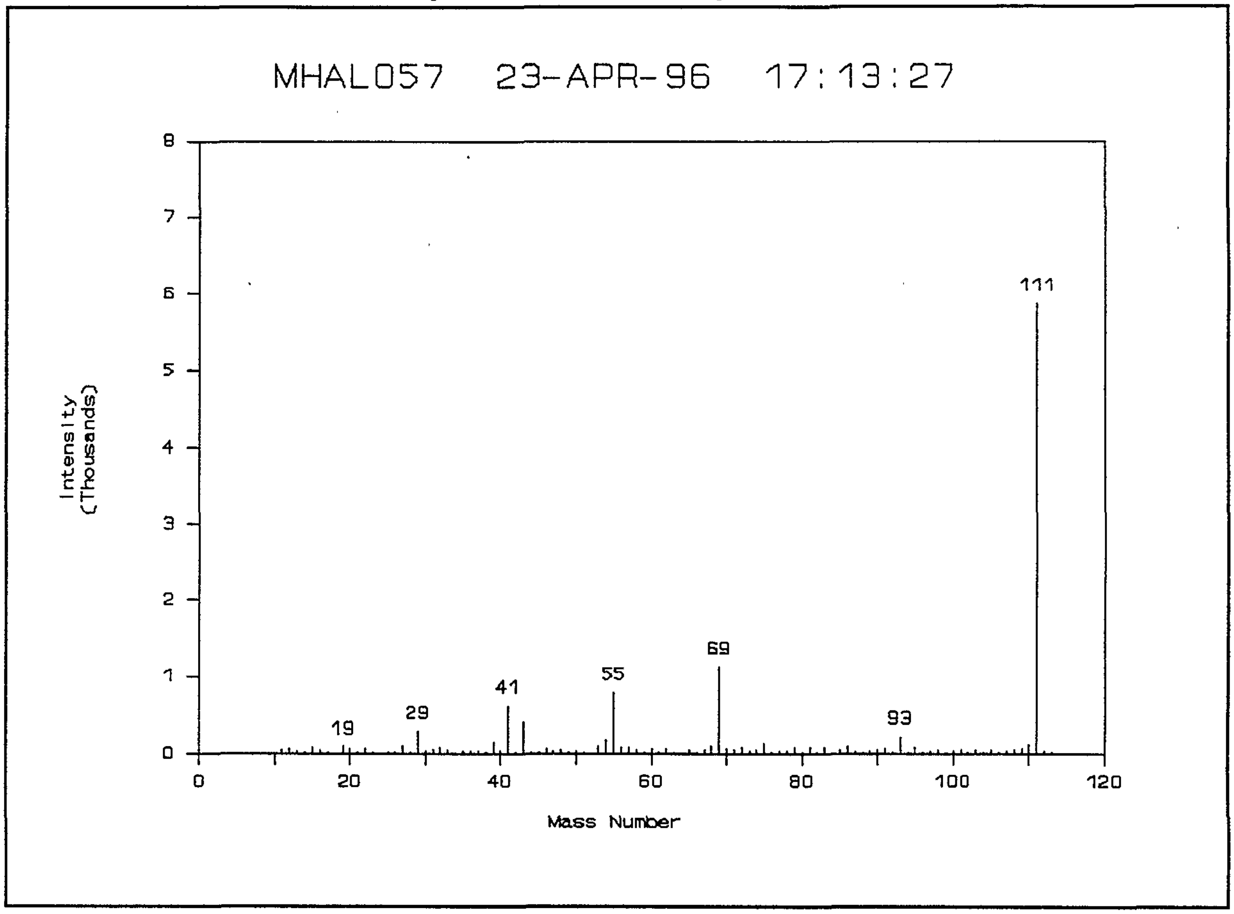

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FIGURE 111
Daughter Ion Spectrum (m/z = 113) at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

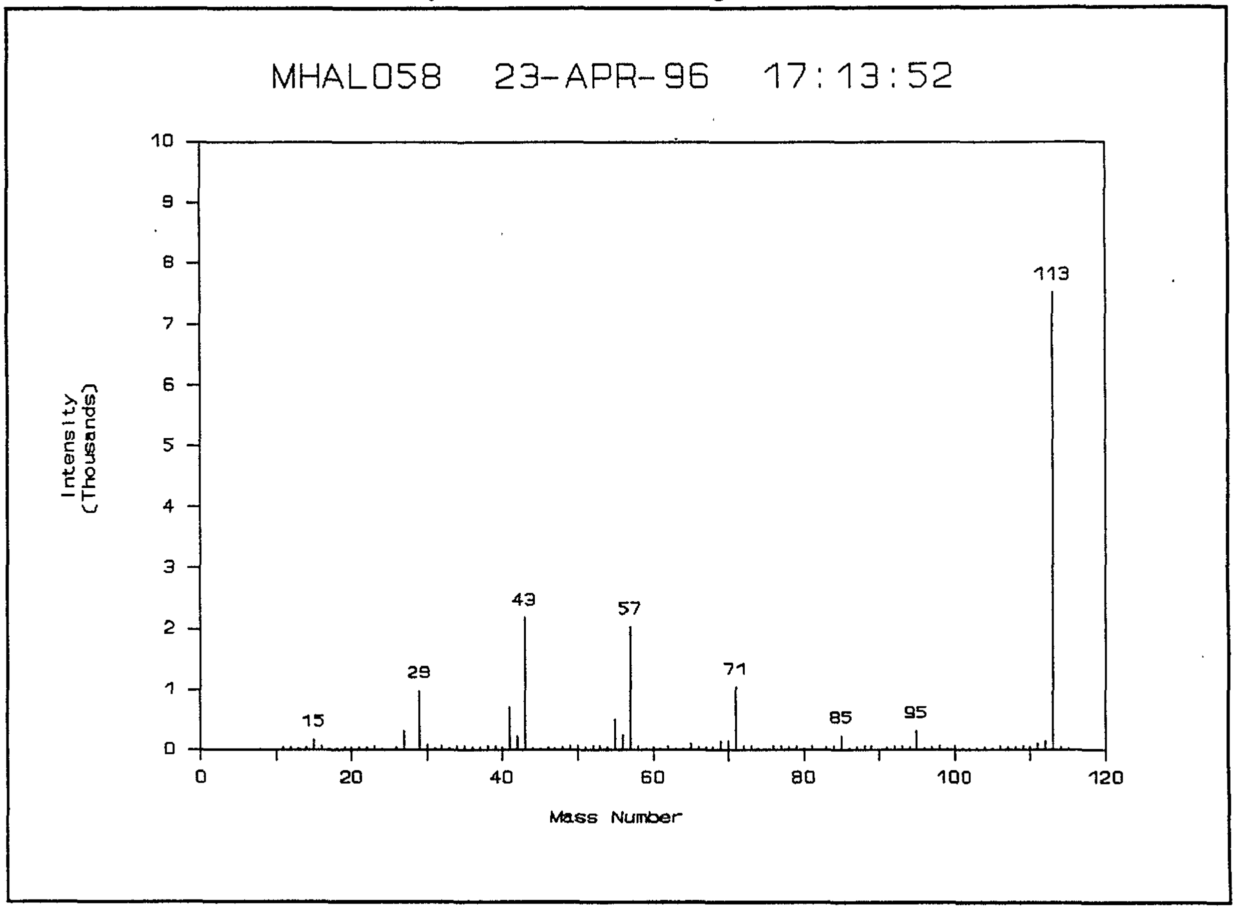

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FIGURE 11m
Daughter Ion Spectrum (m/z = 127) at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

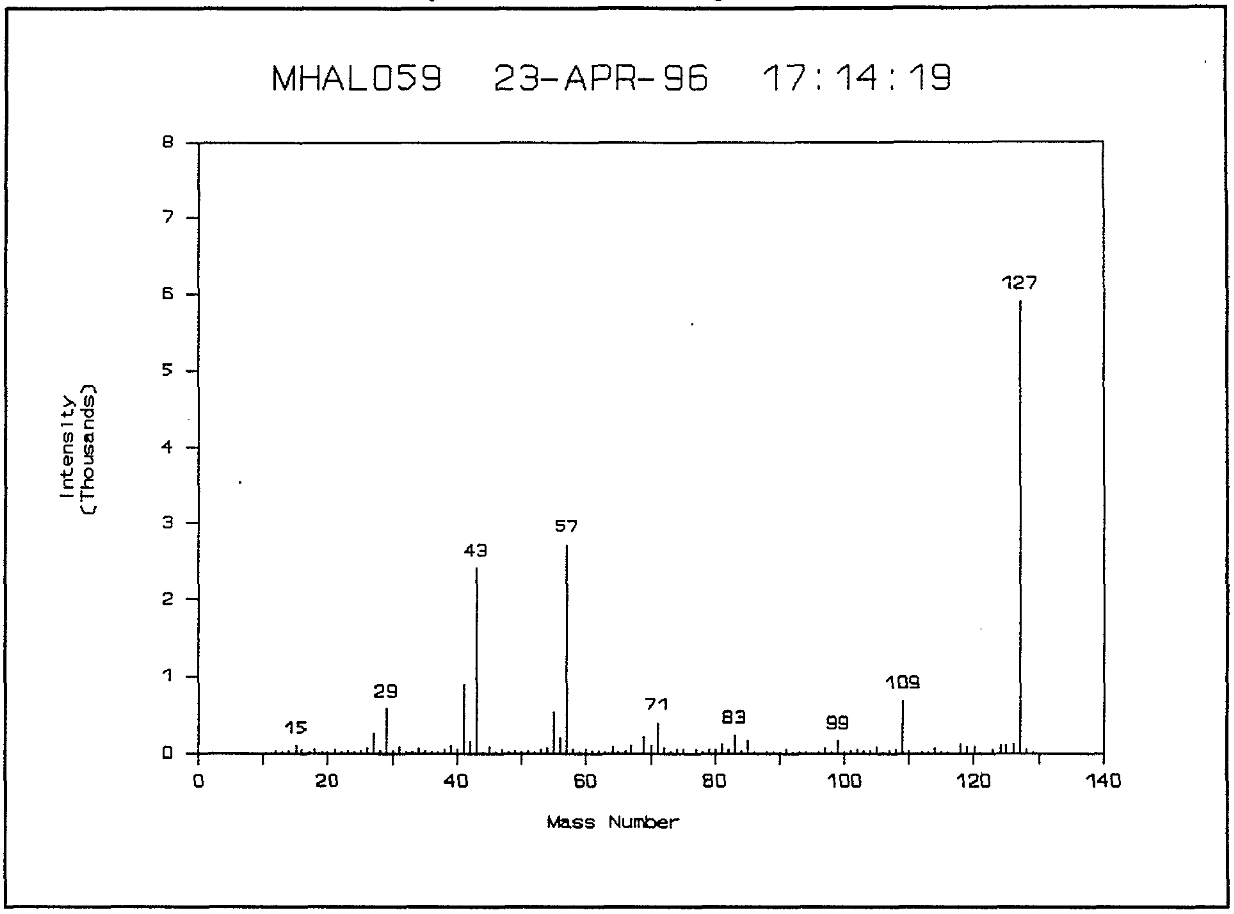

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FIGURE 12e
Background Subtracted Parent Ion Spectrum at Willow Tree Location
Headspace Sample of the Collection Jar
Halby Chemical Site, Wilmington, DE

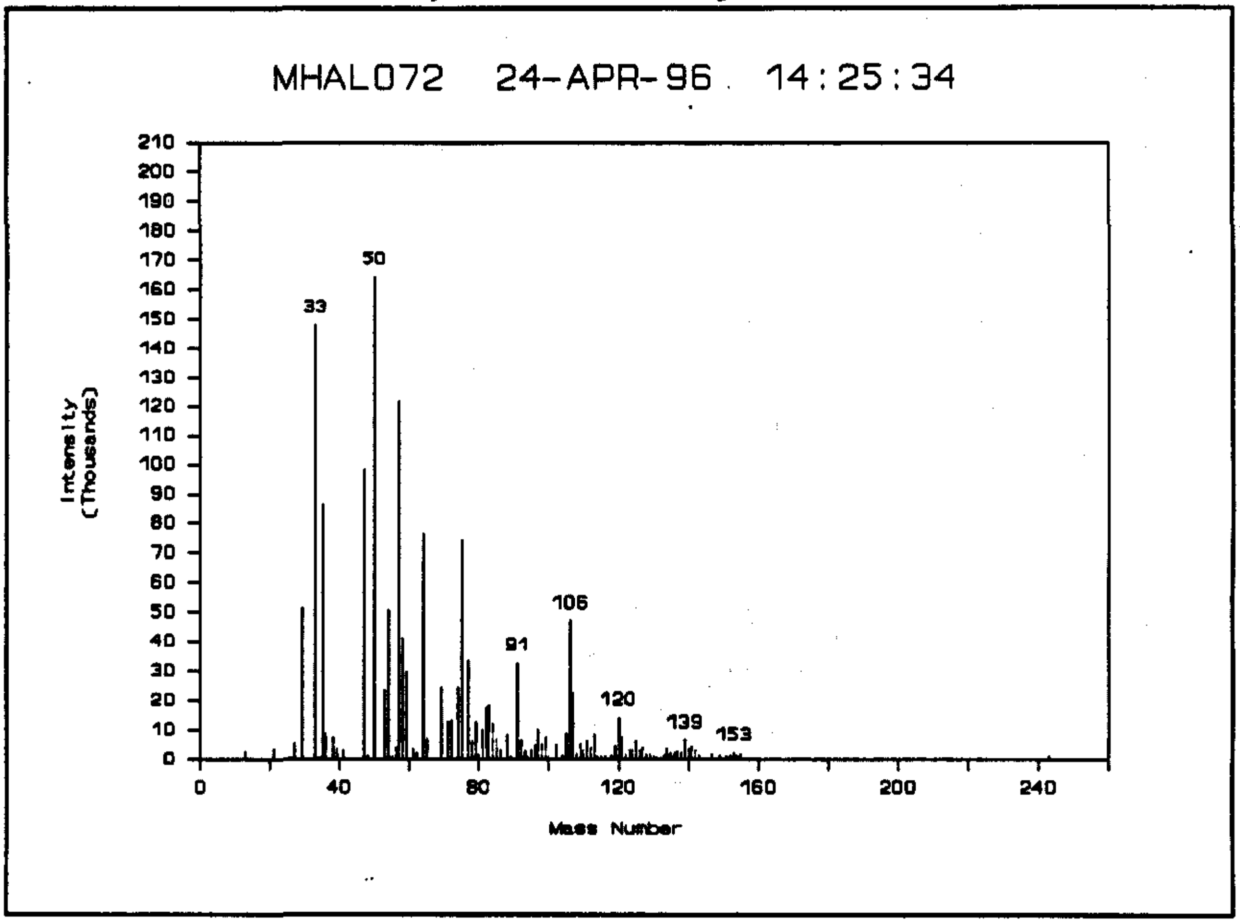

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FIGURE 11n
Daughter Ion Spectrum (m/z = 129) at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

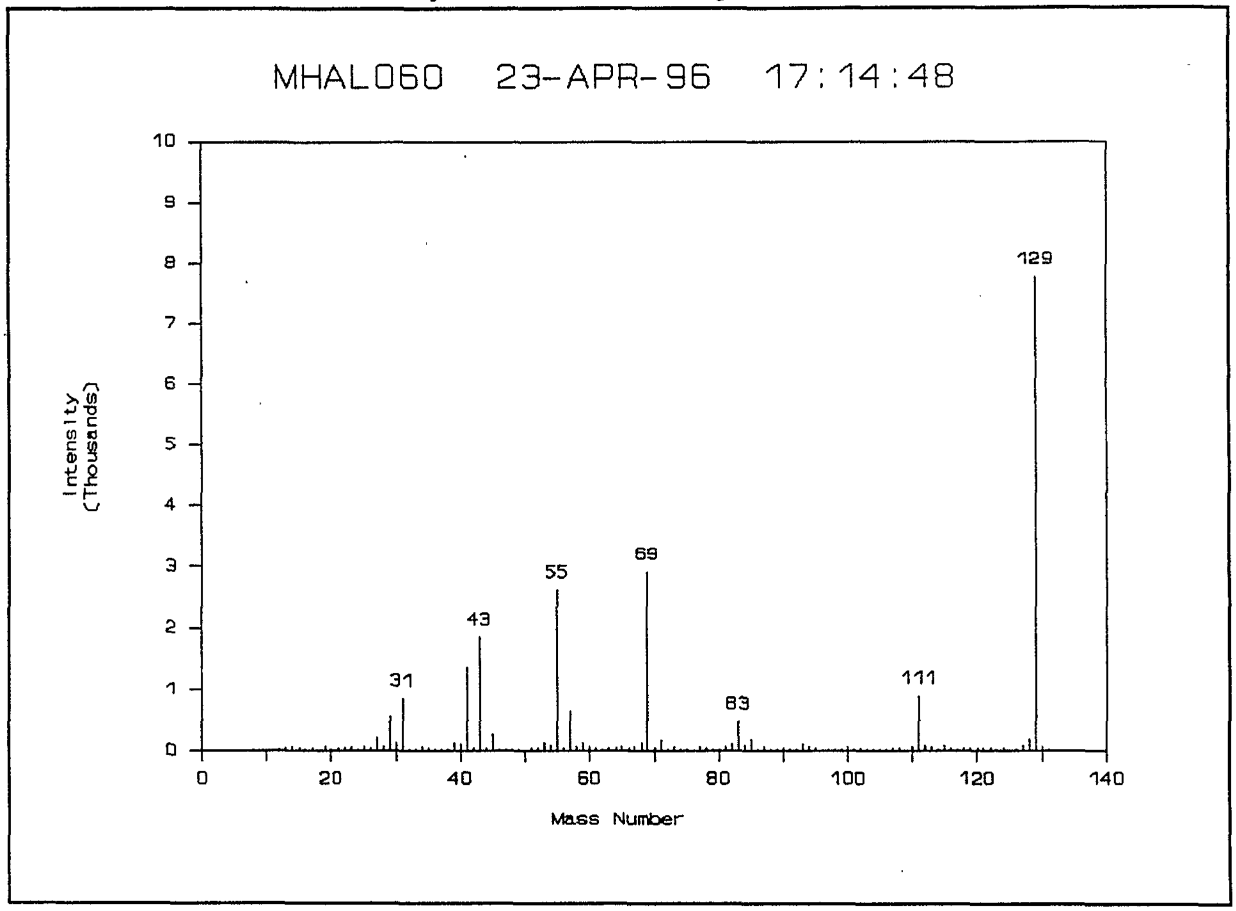

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FIGURE 12f
Background Subtracted Parent Ion Spectrum at Willow Tree Location
Headspace Sample of the Collection Jar
Halby Chemical Site, Wilmington, DE

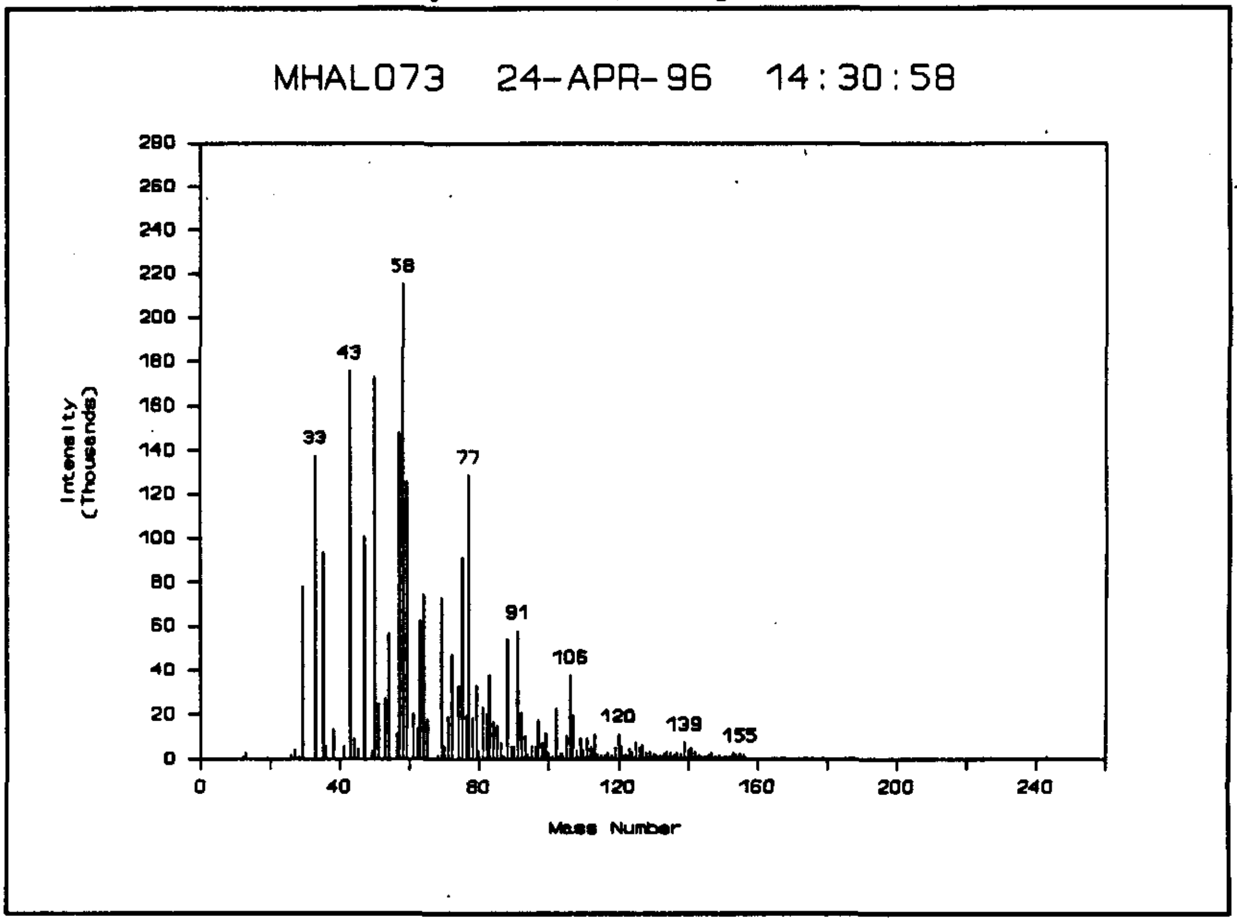

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FIGURE 11o
Daughter Ion Spectrum (m/z = 147) at Enlarged Pit 1 - Hose in Pit
Halby Chemical Site, Wilmington, DE

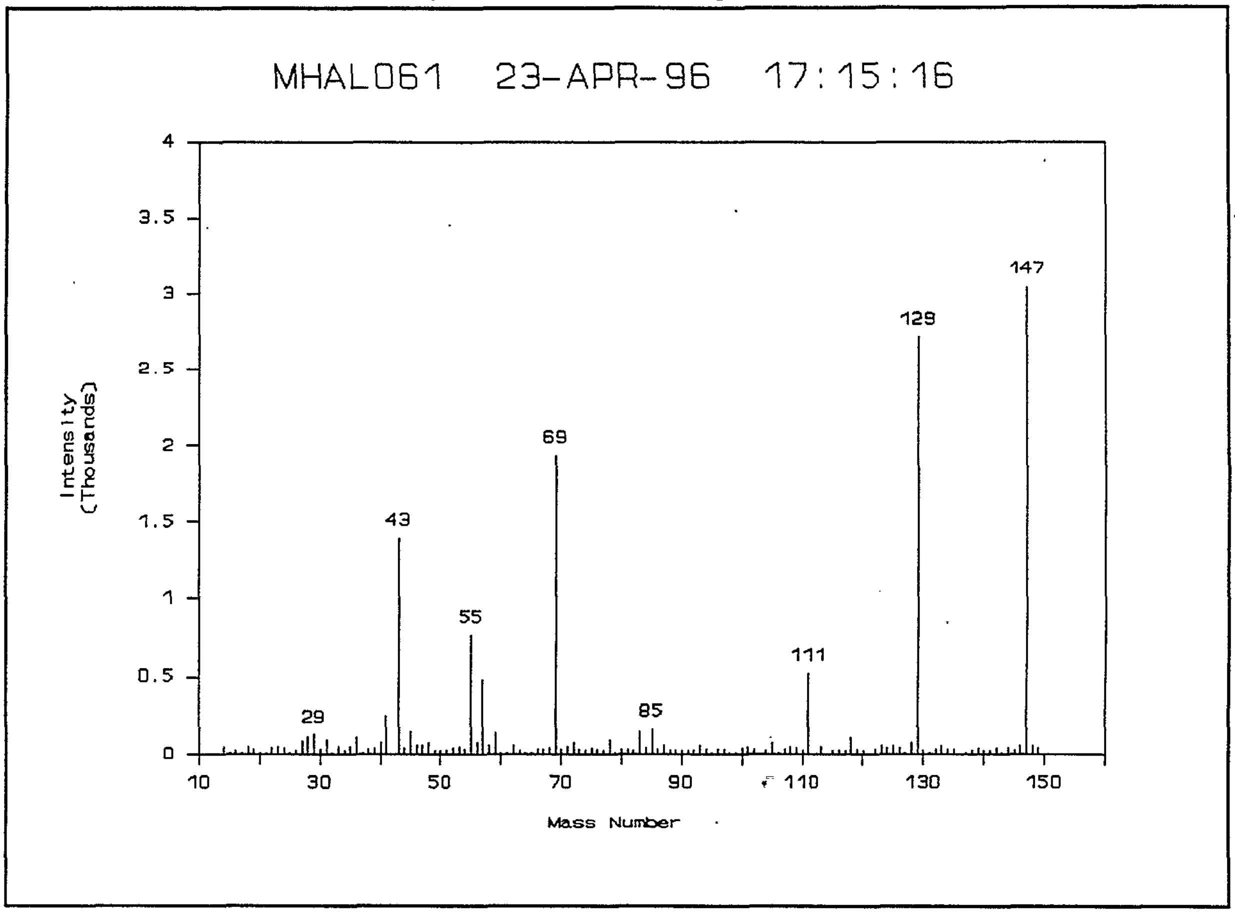

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FIGURE 12g
Daughter Ion Spectrum (m/z = 77) at Willow Tree Location
Headspace Sample of the Collection Jar
Halby Chemical Site, Wilmington, DE

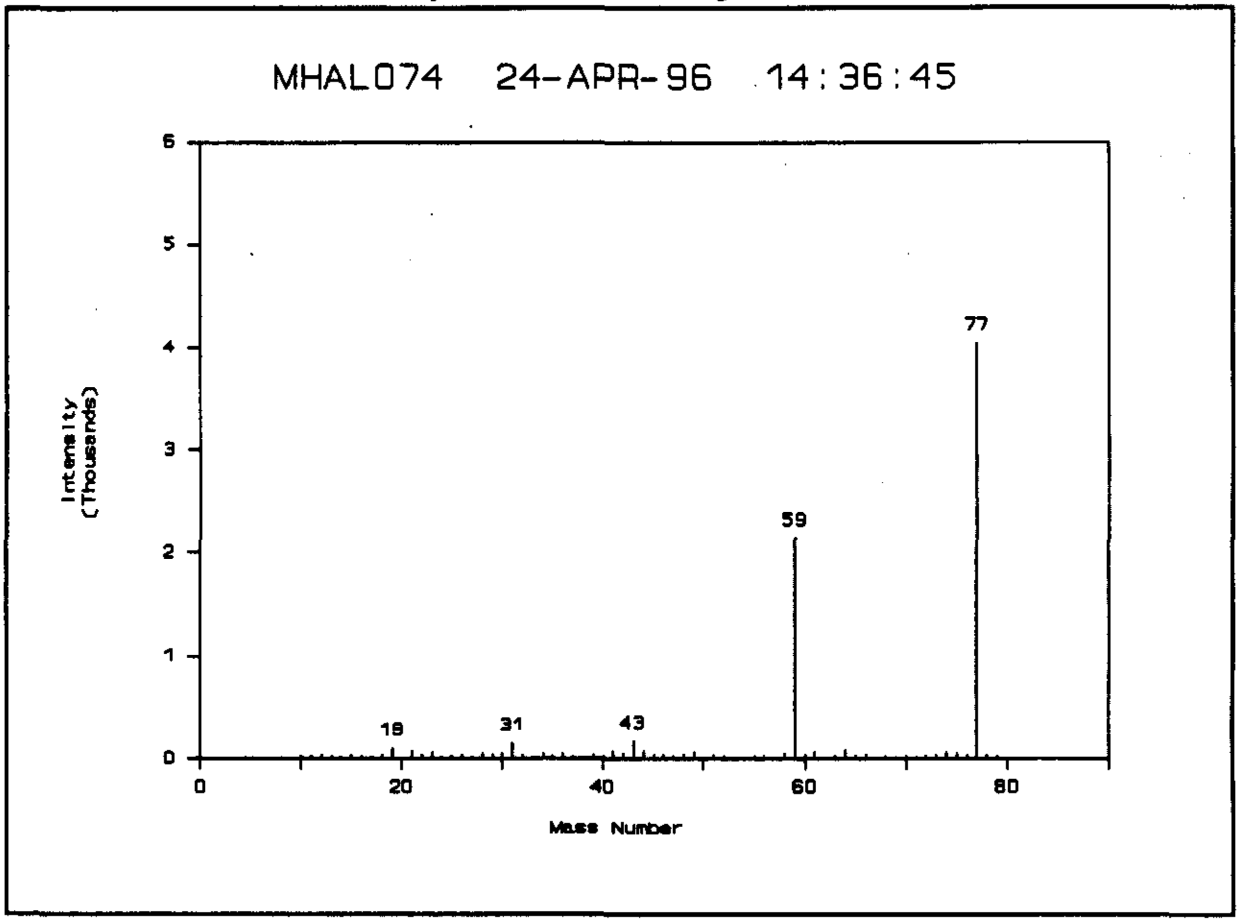

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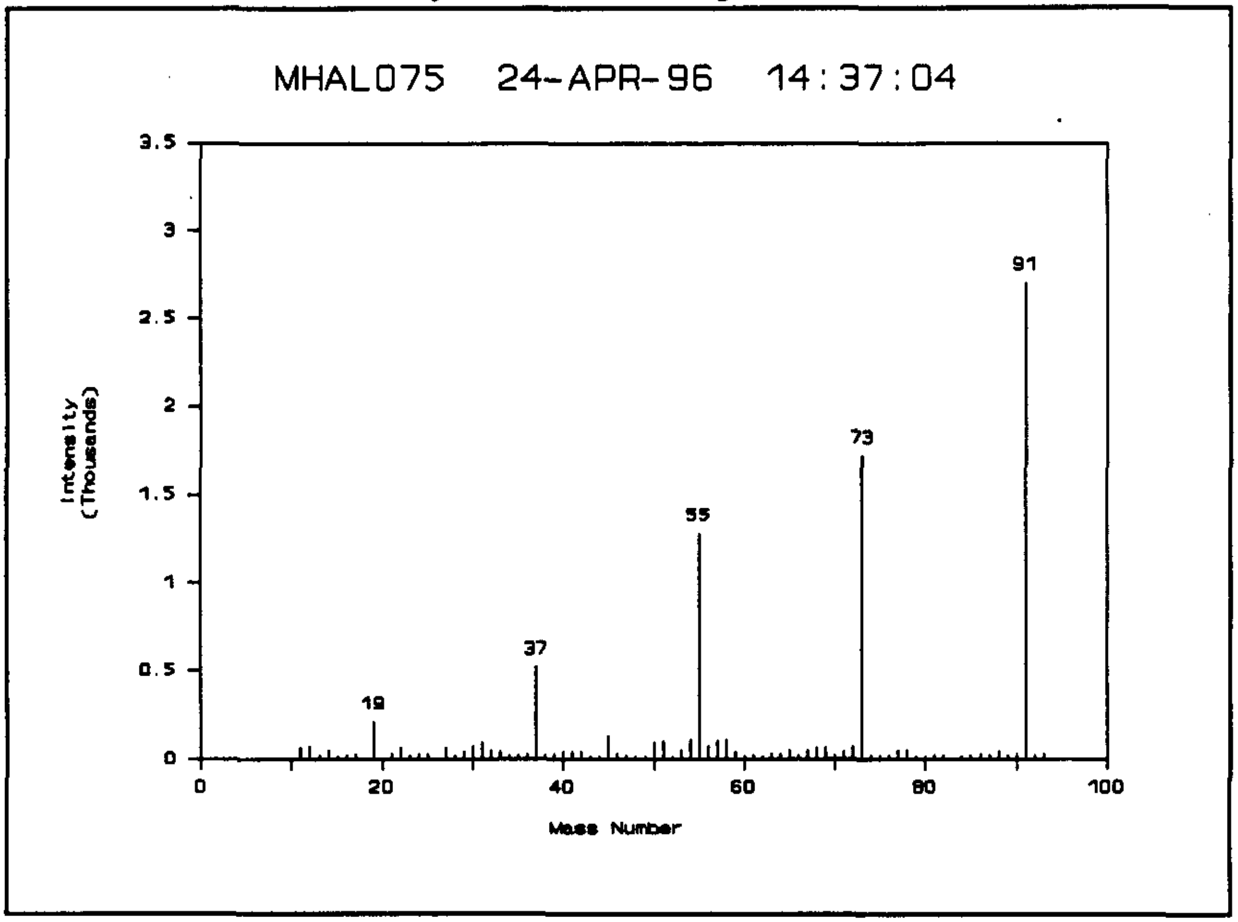
FIGURE 12h
Daughter Ion Spectrum (m/z = 91) at Willow Tree Location
Headspace Sample of the Collection Jar
Halby Chemical Site, Wilmington, DE



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Soil Sample at the Willow Tree Location

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FIGURE 12a
Background Subtracted Parent Ion Spectrum at Willow Tree Location
Headspace Sample in an Impinger
Halby Chemical Site, Wilmington, DE

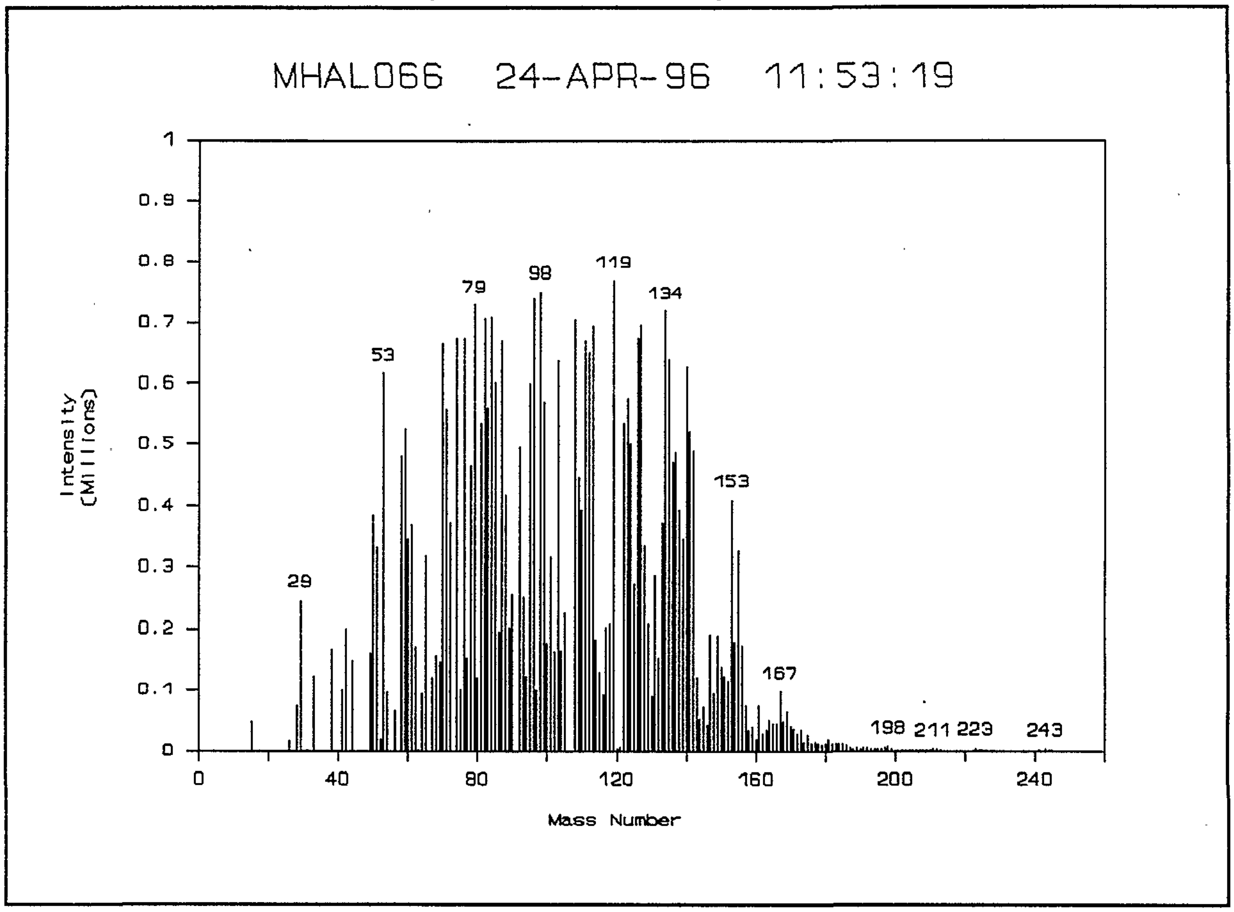

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FIGURE 12i
Daughter Ion Spectrum (m/z = 106) at Willow Tree Location
Headspace Sample of the Collection Jar
Halby Chemical Site, Wilmington, DE

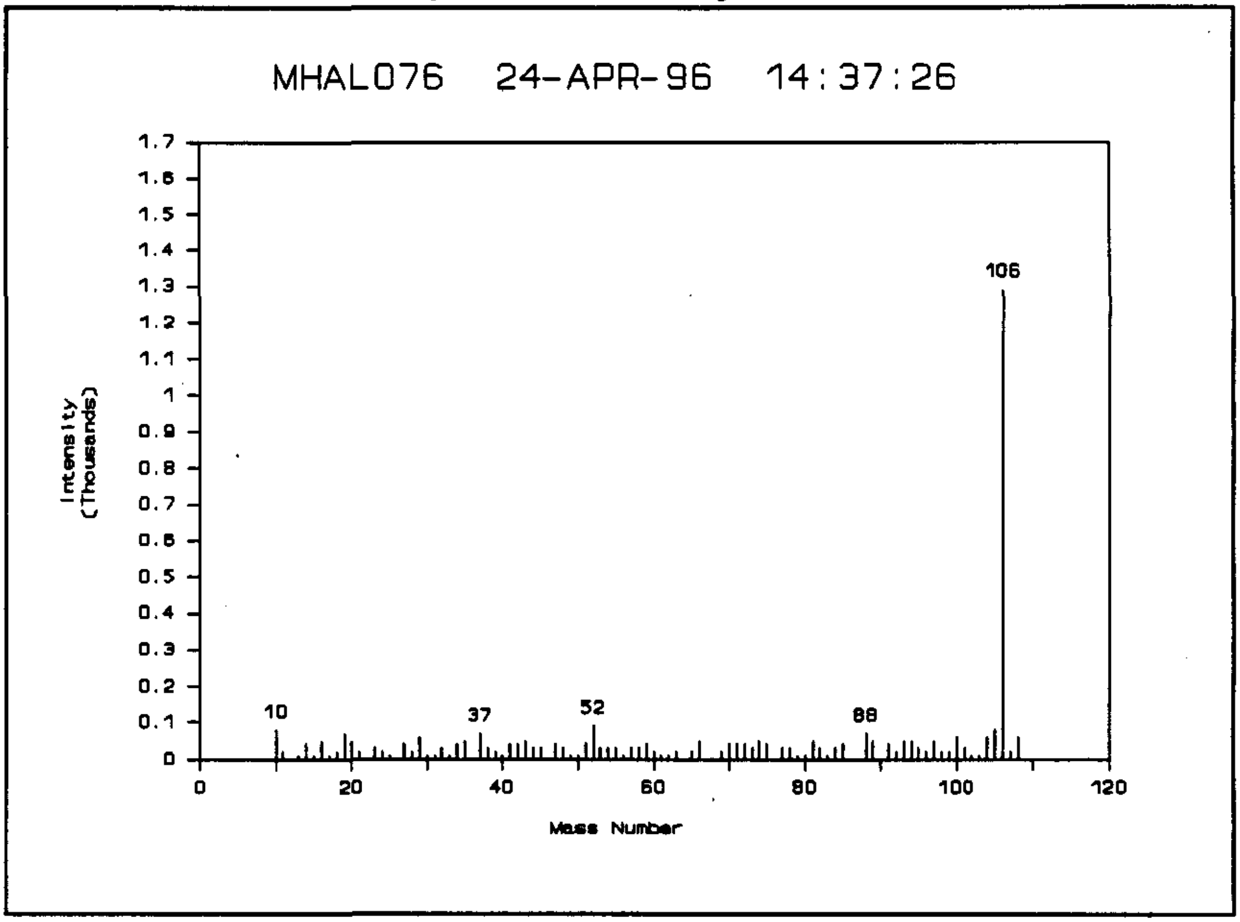

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FIGURE 12j
Daughter Ion Spectrum (m/z = 120) at Willow Tree Location
Headspace Sample of the Collection Jar
Halby Chemical Site, Wilmington, DE

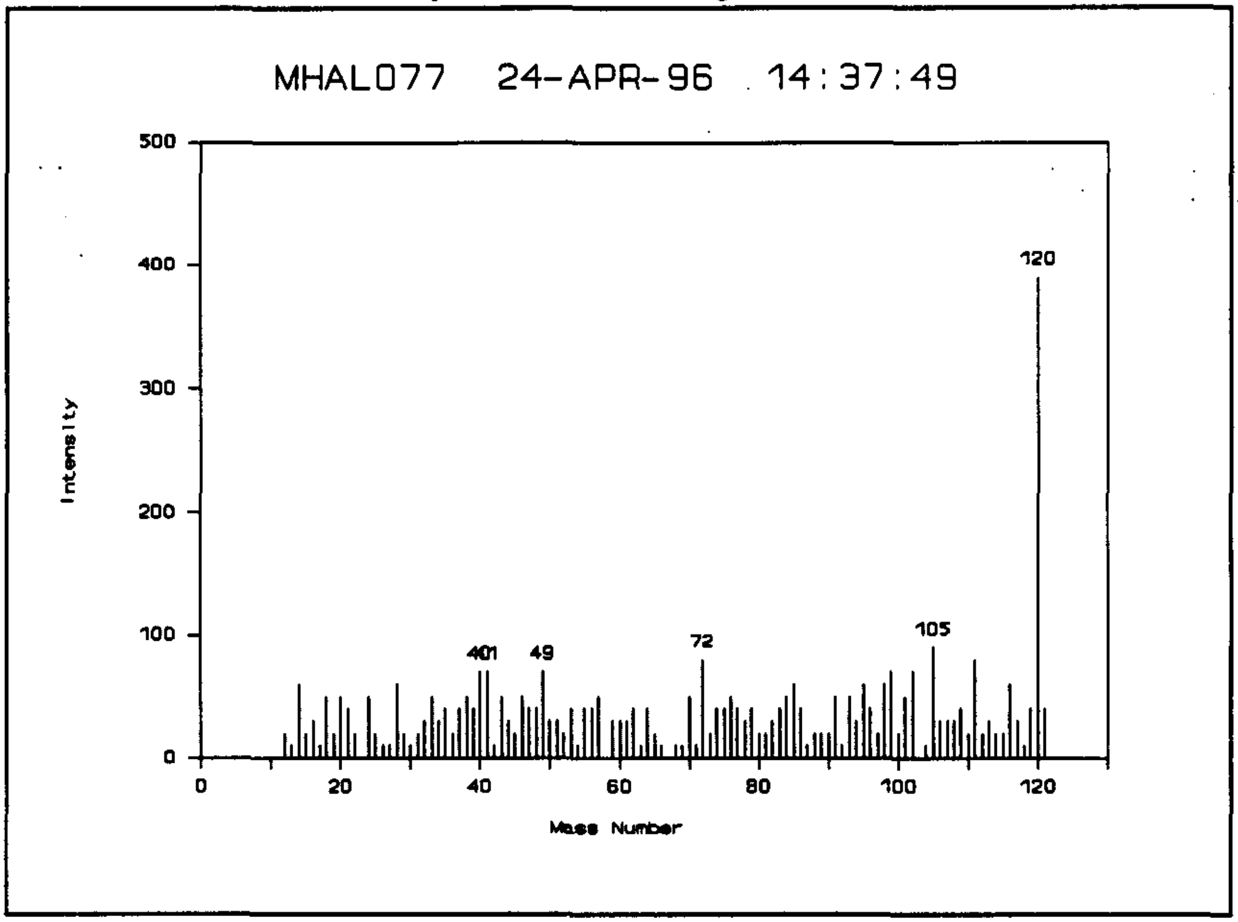

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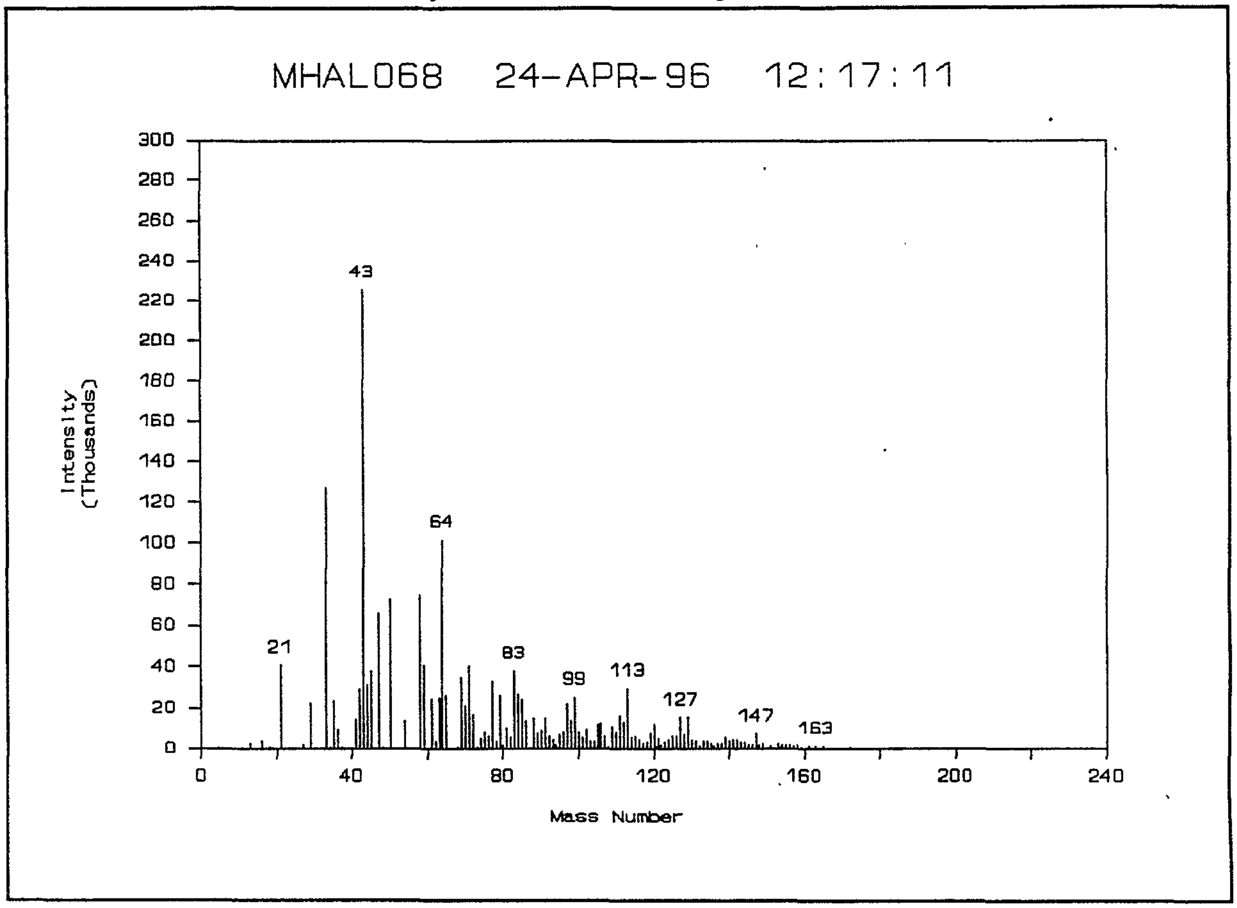
FIGURE 12b
Background Subtracted Parent Ion Spectrum at Willow Tree Location
Headspace Sample in a Syringe at Syringe Drive Speed = 6
Halby Chemical Site, Wilmington, DE



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Pit 1 - Hose in the Pit

FIGURE 12c
Background Subtracted Parent Ion Spectrum at Willow Tree Location
Headspace Sample in an Impinger
Halby Chemical Site, Wilmington, DE

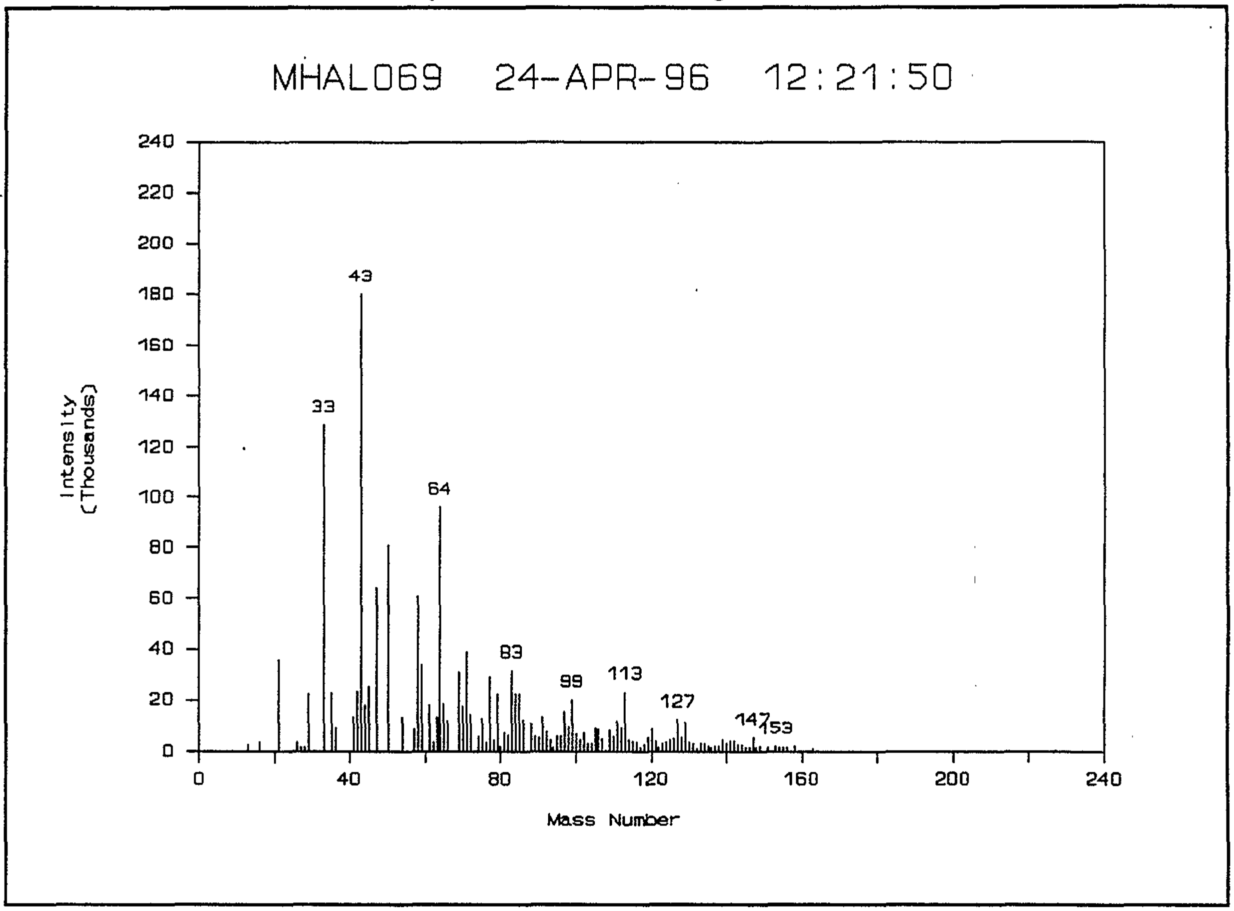

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FIGURE 13a
Stationary Monitoring at Pit 1 - Hose in the Pit
for Vinyl Chloride, Benzene, and Ethylisothiocyanate
Halby Chemical Site, Wilmington, DE

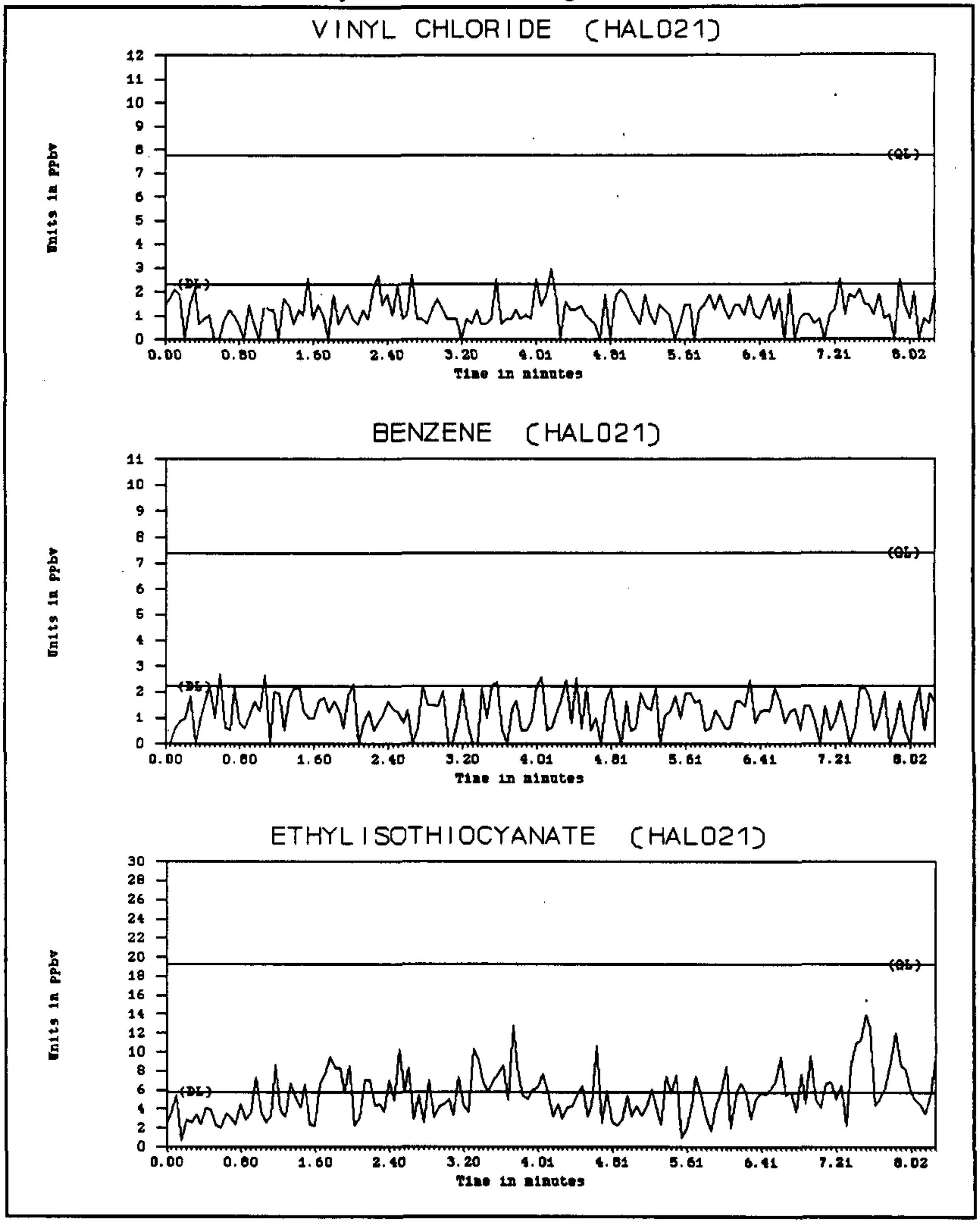

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FIGURE 13b
Stationary Monitoring at Pit 1 - Hose in the Pit
for Toluene, Trans-1,2-Dichloroethene, and Xylene
Halby Chemical Site, Wilmington, DE

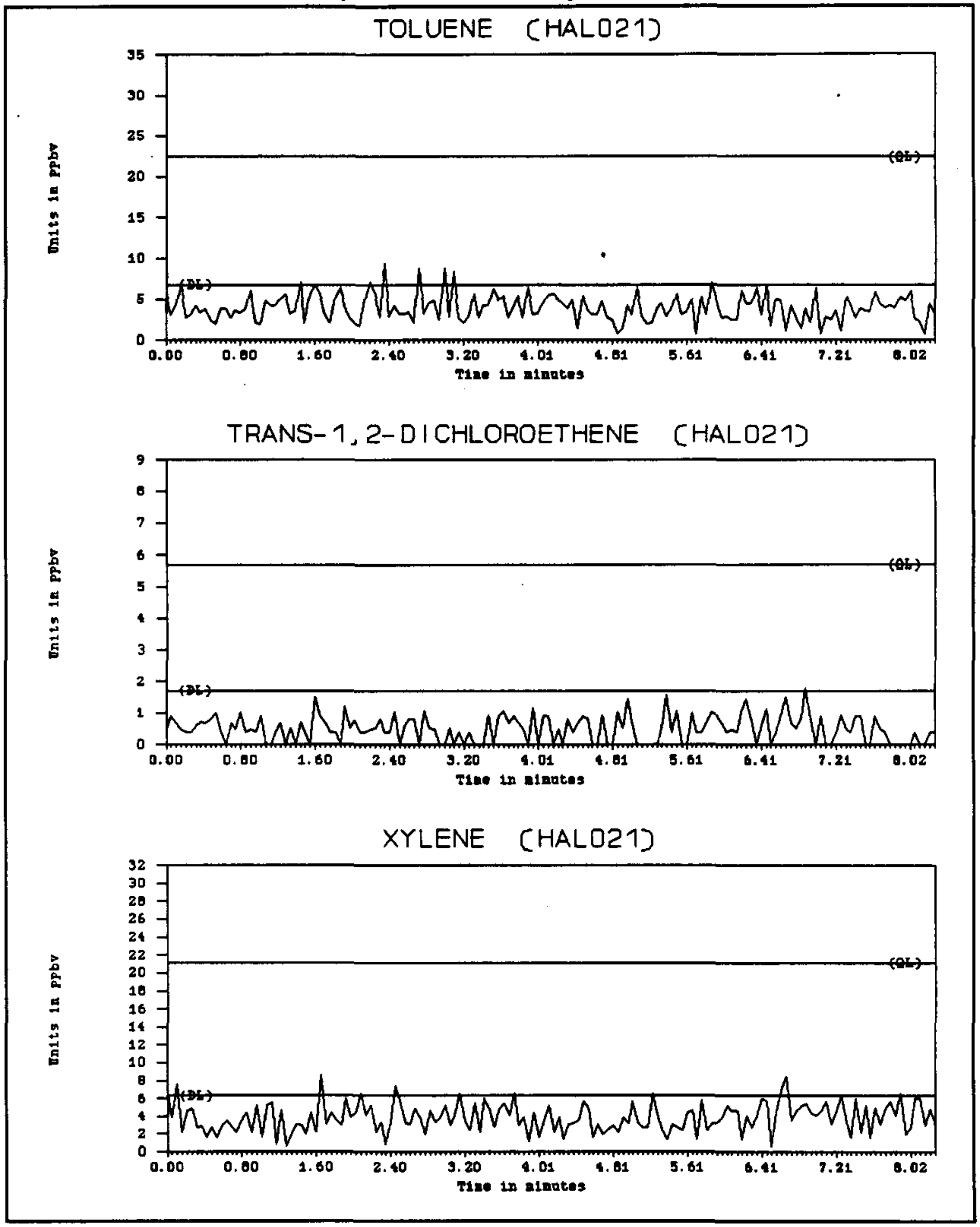

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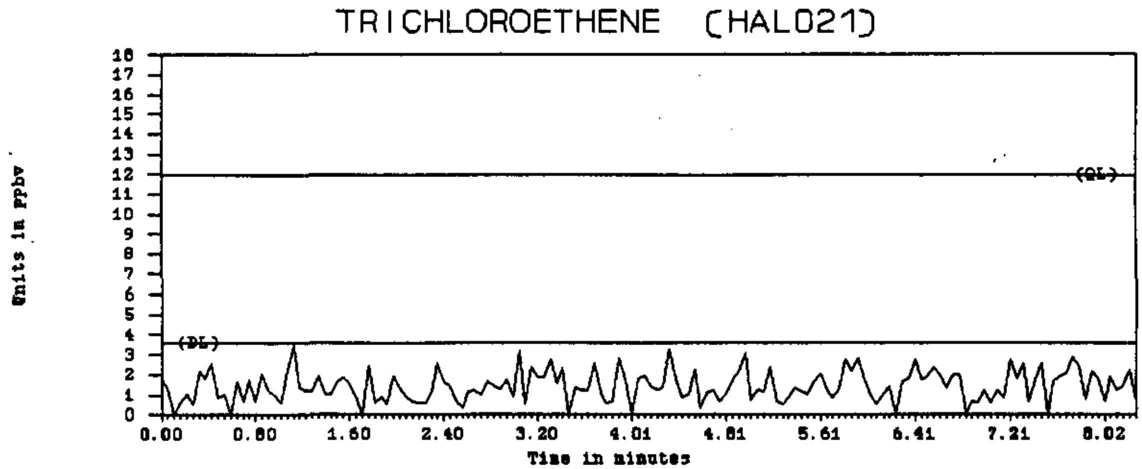
FIGURE 13c
Stationary Monitoring at Pit 1 - Hose in the Pit
for Trichloroethene and Tetrachloroethene
Halby Chemical Site, Wilmington, DE



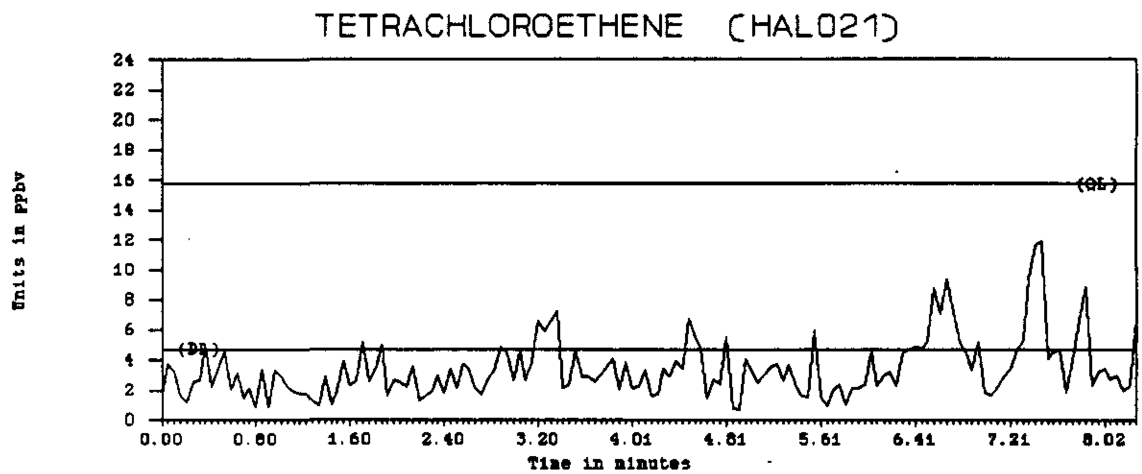


FIGURE 13d
Background Subtracted Parent Ion Spectrum at Pit 1 - Hose in the Pit
Halby Chemical Site, Wilmington, DE

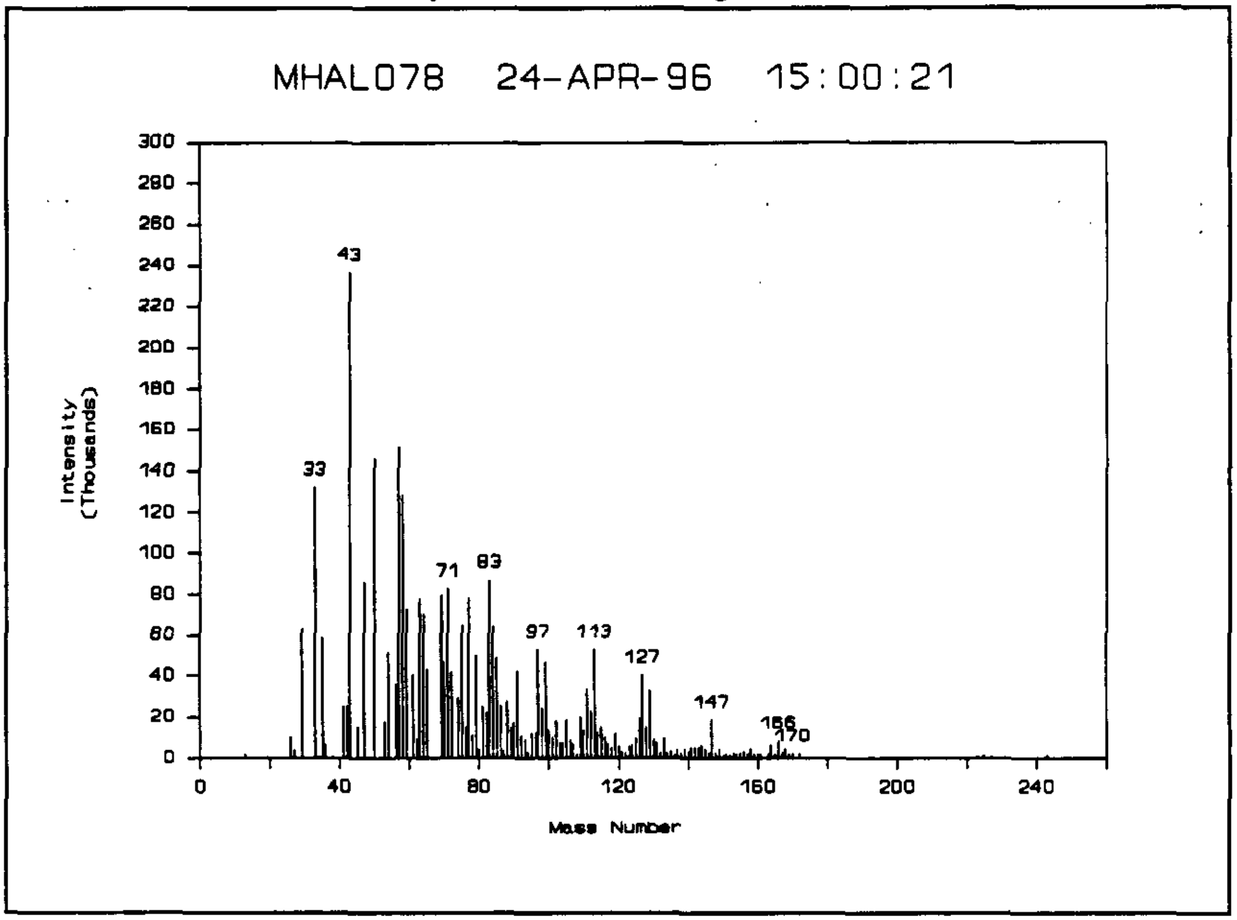


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FIGURE 13e
Daughter Ion Spectrum (m/z = 69) at Pit 1 - Hose in the Pit
Halby Chemical Site, Wilmington, DE

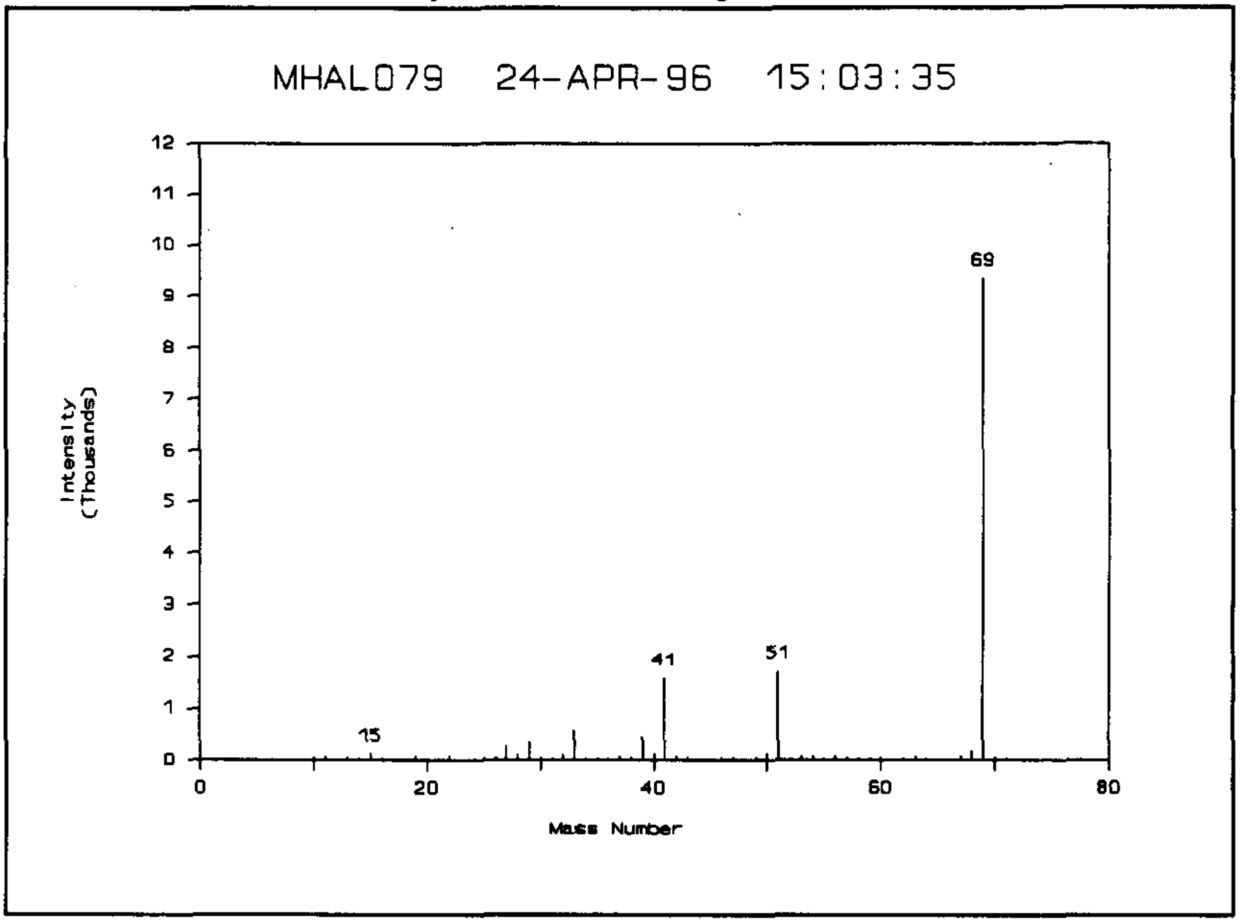

FIGURE 13f
Daughter Ion Spectrum (m/z = 71) at Pit 1 - Hose in the Pit
Halby Chemical Site, Wilmington, DE

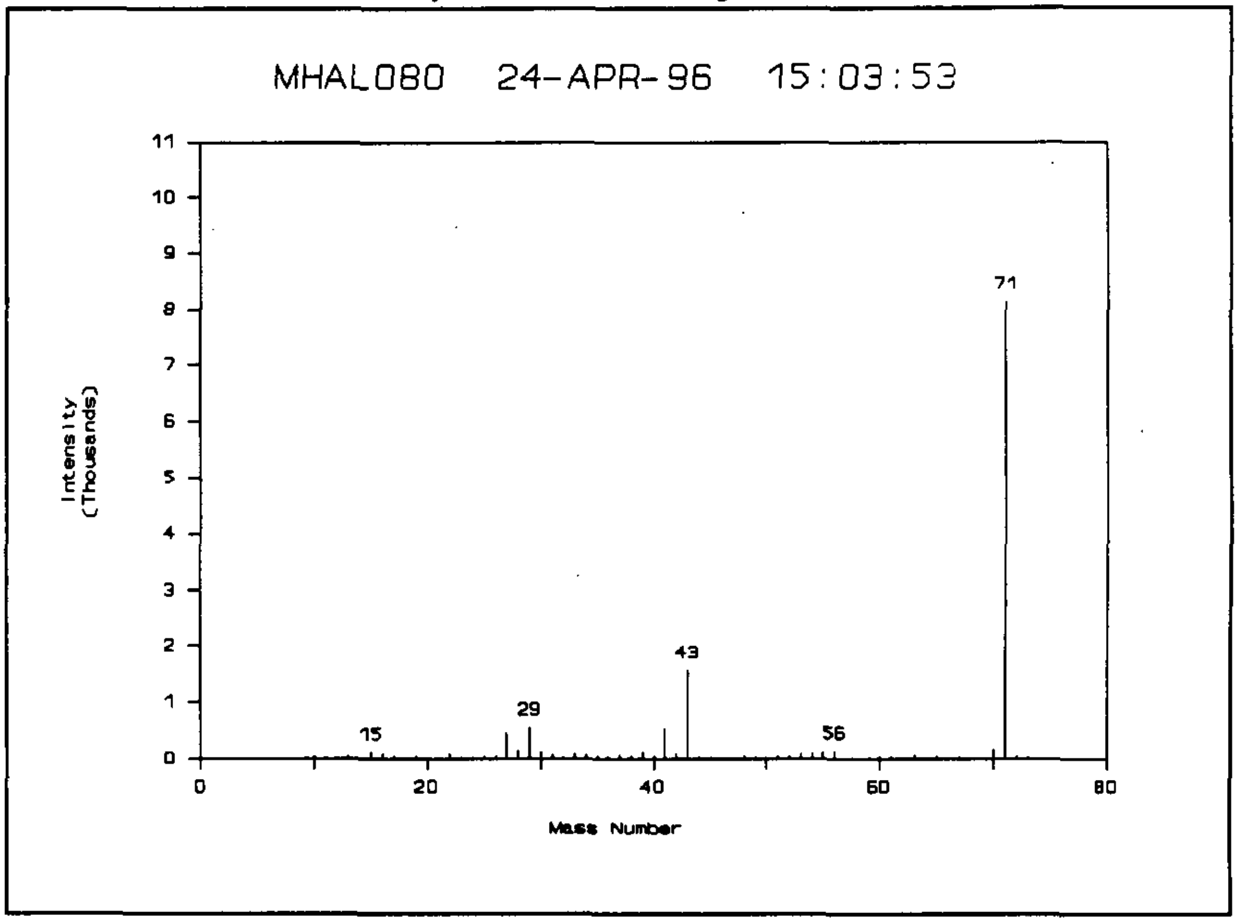

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FIGURE 13g
Daughter Ion Spectrum (m/z = 83) at Pit 1 - Hose in the Pit
Halby Chemical Site, Wilmington, DE

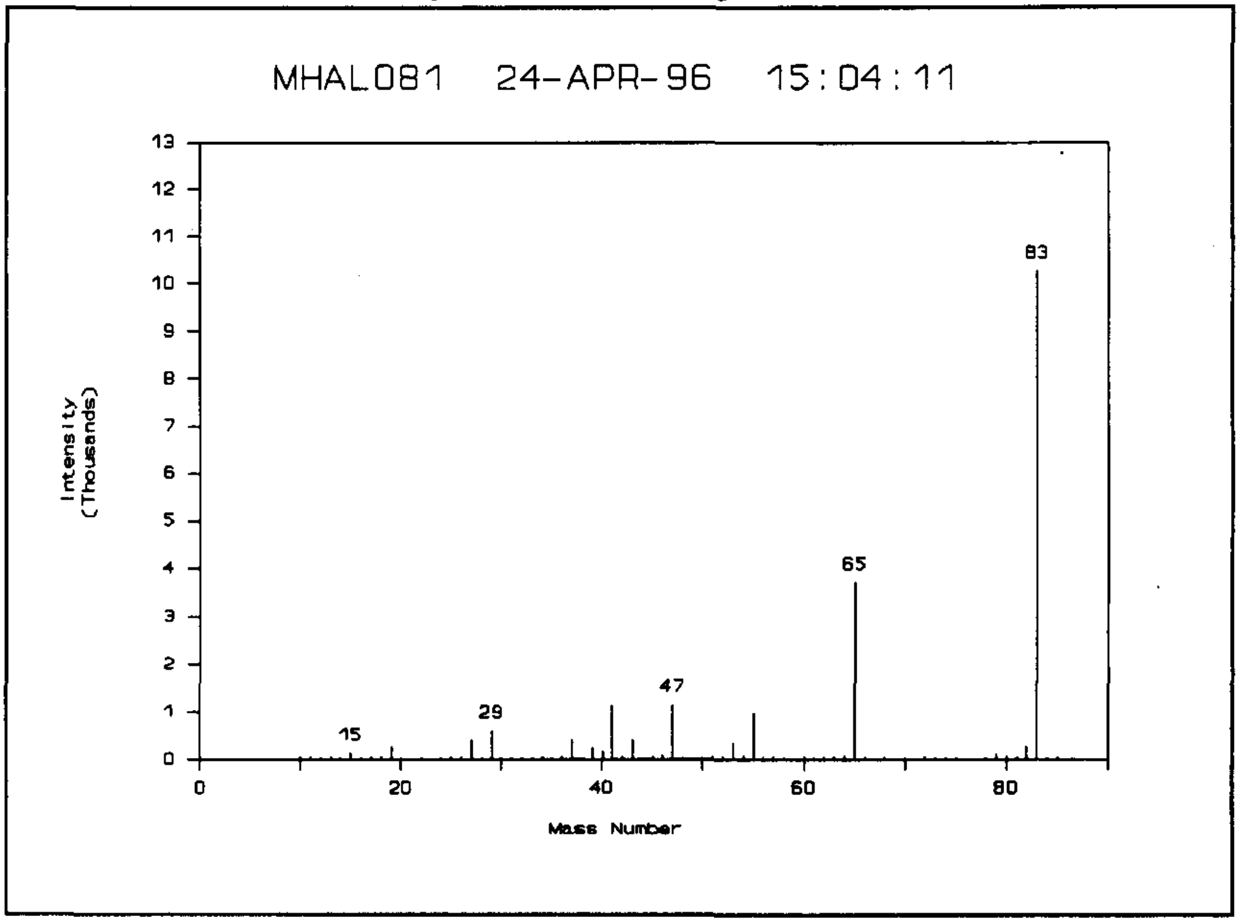

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FIGURE 13h
Daughter Ion Spectrum (m/z = 97) at Pit 1 - Hose in the Pit
Halby Chemical Site, Wilmington, DE

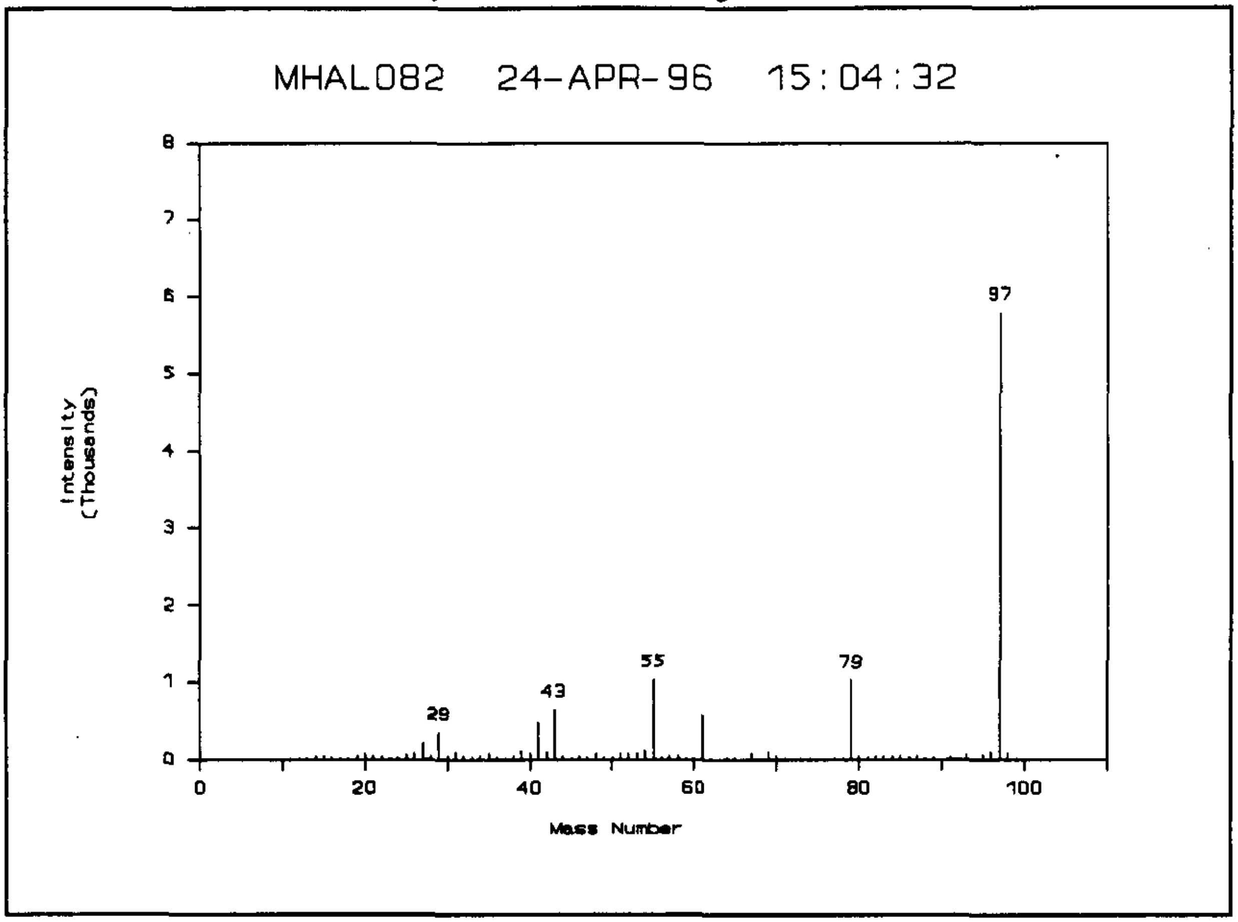

FIGURE 13i
Daughter Ion Spectrum (m/z = 99) at Pit 1 - Hose in the Pit
Halby Chemical Site, Wilmington, DE

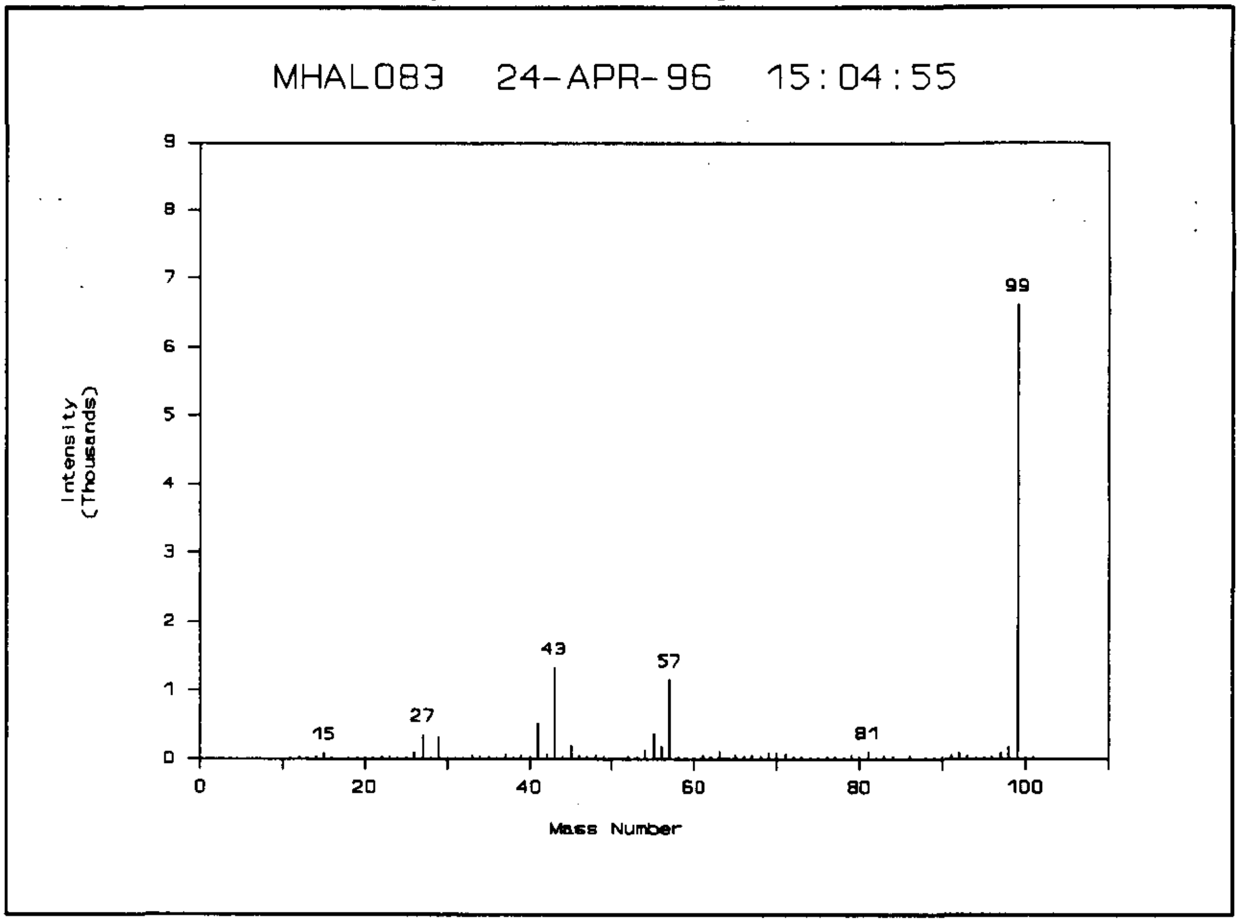

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FIGURE 13j
Daughter Ion Spectrum (m/z = 113) at Pit 1 - Hose in the Pit
Halby Chemical Site, Wilmington, DE

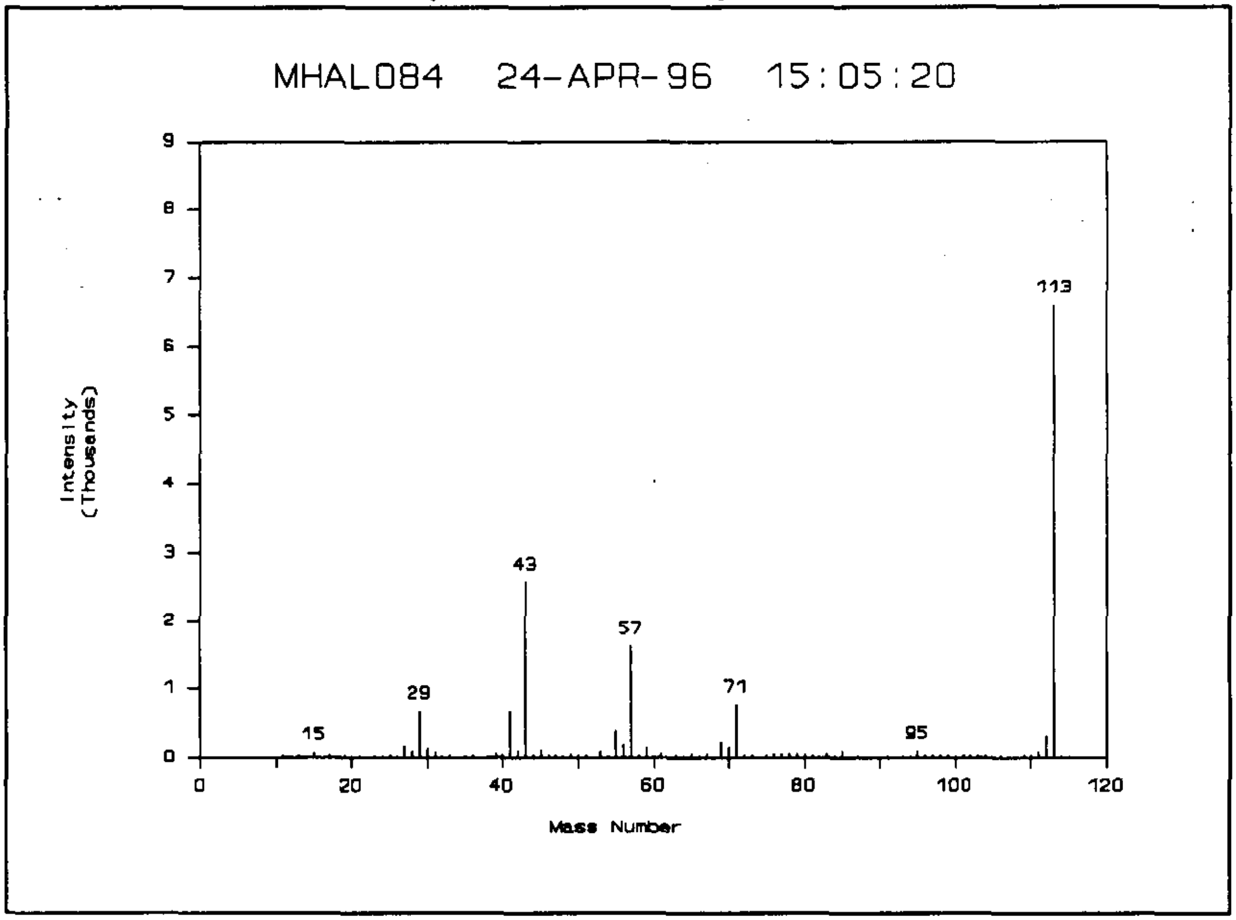

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FIGURE 13k
Daughter Ion Spectrum (m/z = 127) at Pit 1 - Hose in the Pit
Halby Chemical Site, Wilmington, DE

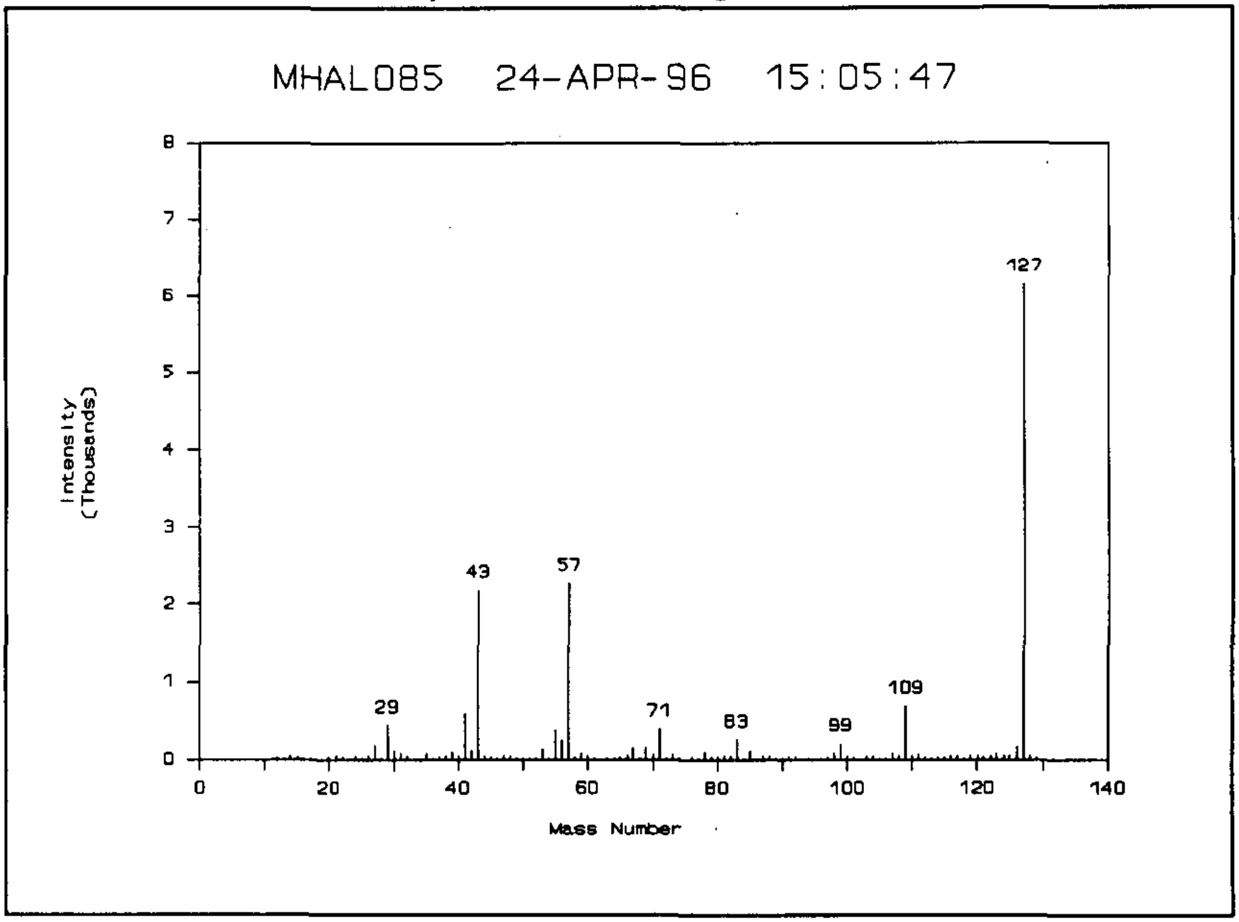

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FIGURE 131
Daughter Ion Spectrum (m/z = 129) at Pit 1 - Hose in the Pit
Halby Chemical Site, Wilmington, DE

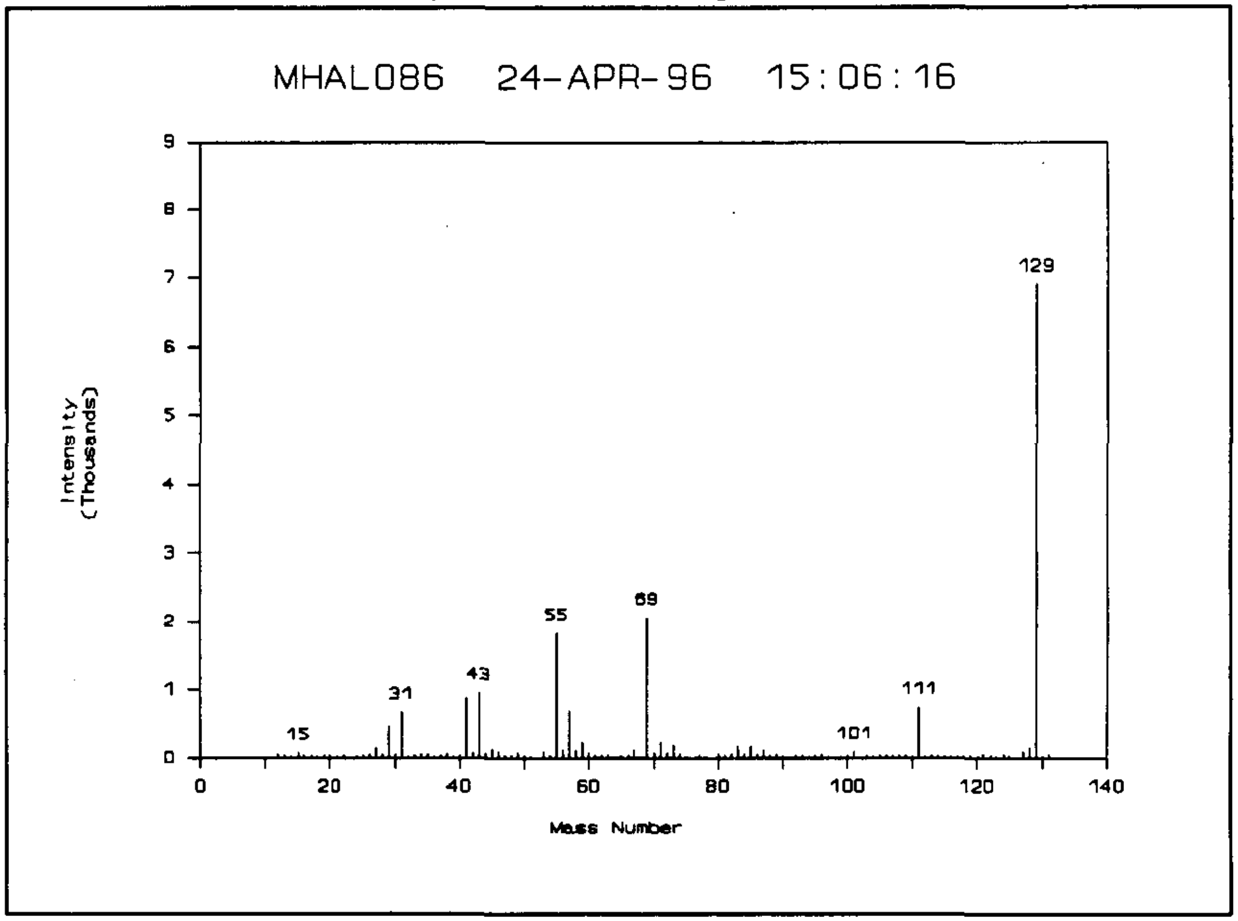

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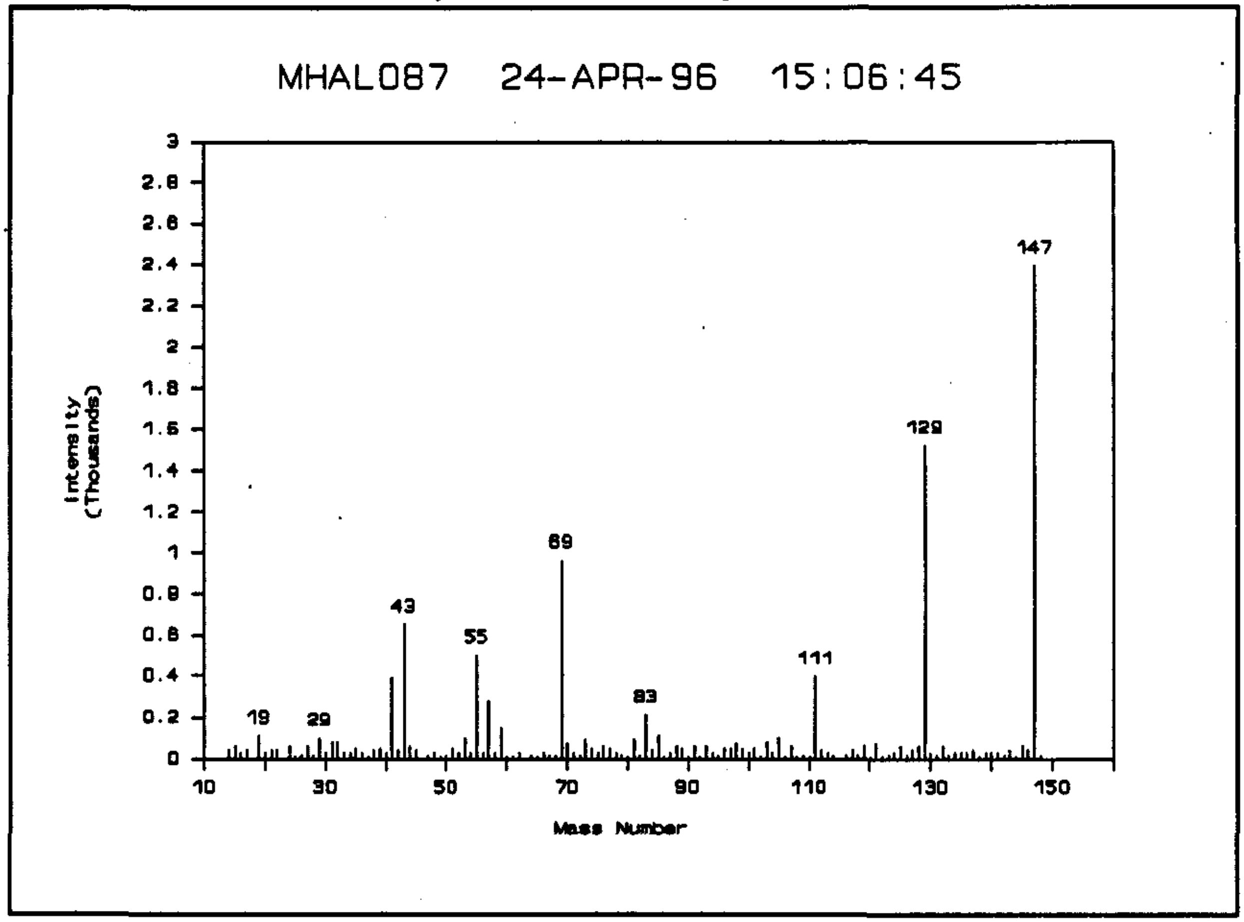
FIGURE 13m
Daughter Ion Spectrum (m/z = 147) at Pit 1 - Hose in the Pit
Halby Chemical Site, Wilmington, DE



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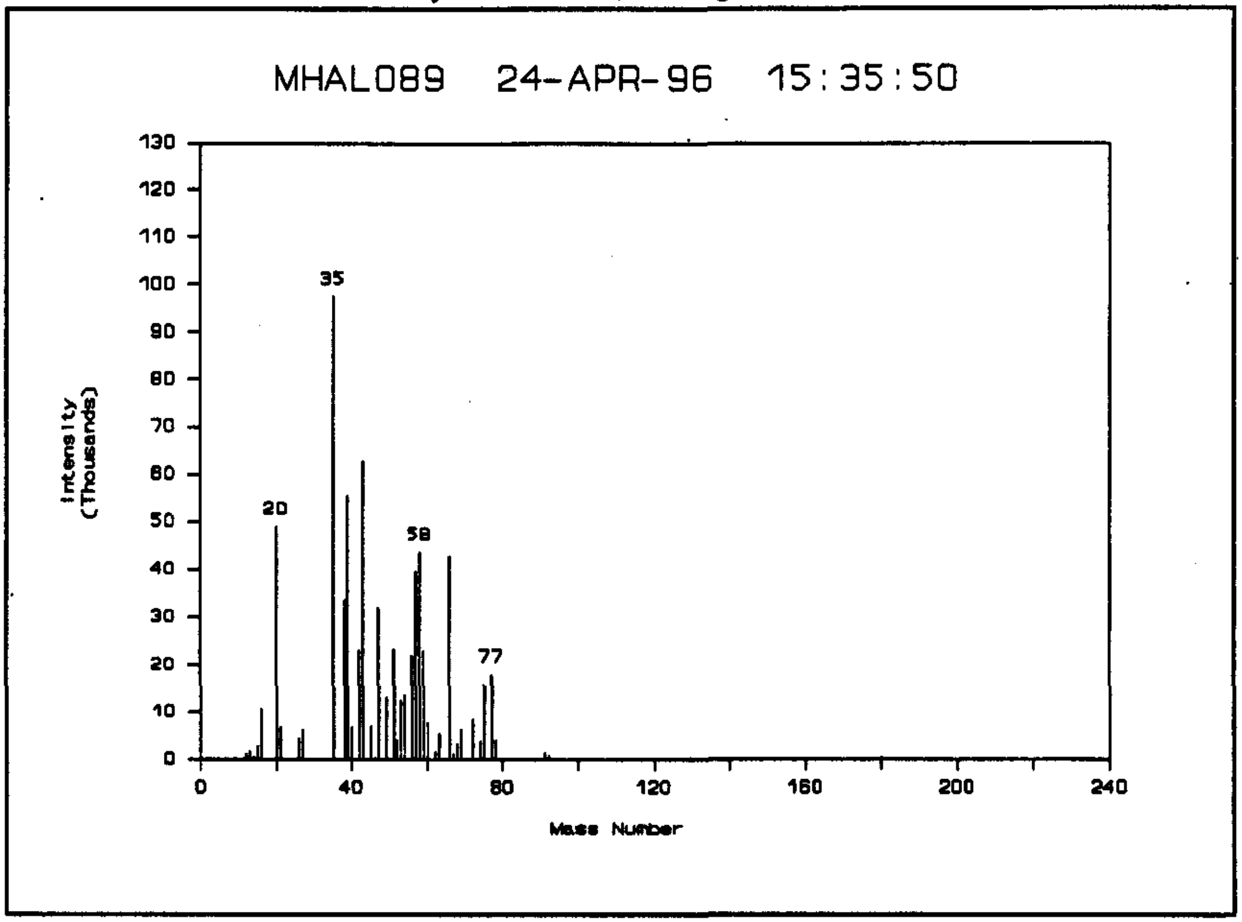
Soil Sample from BIO-7

FIGURE 14a
Background Subtracted Parent Ion Spectrum at BIO-7 - Sample Headspace
Halby Chemical Site, Wilmington, DE



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Pit 1

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FIGURE 15a
Background Subtracted Parent Ion Spectrum at Pit 1
Halby Chemical Site, Wilmington, DE

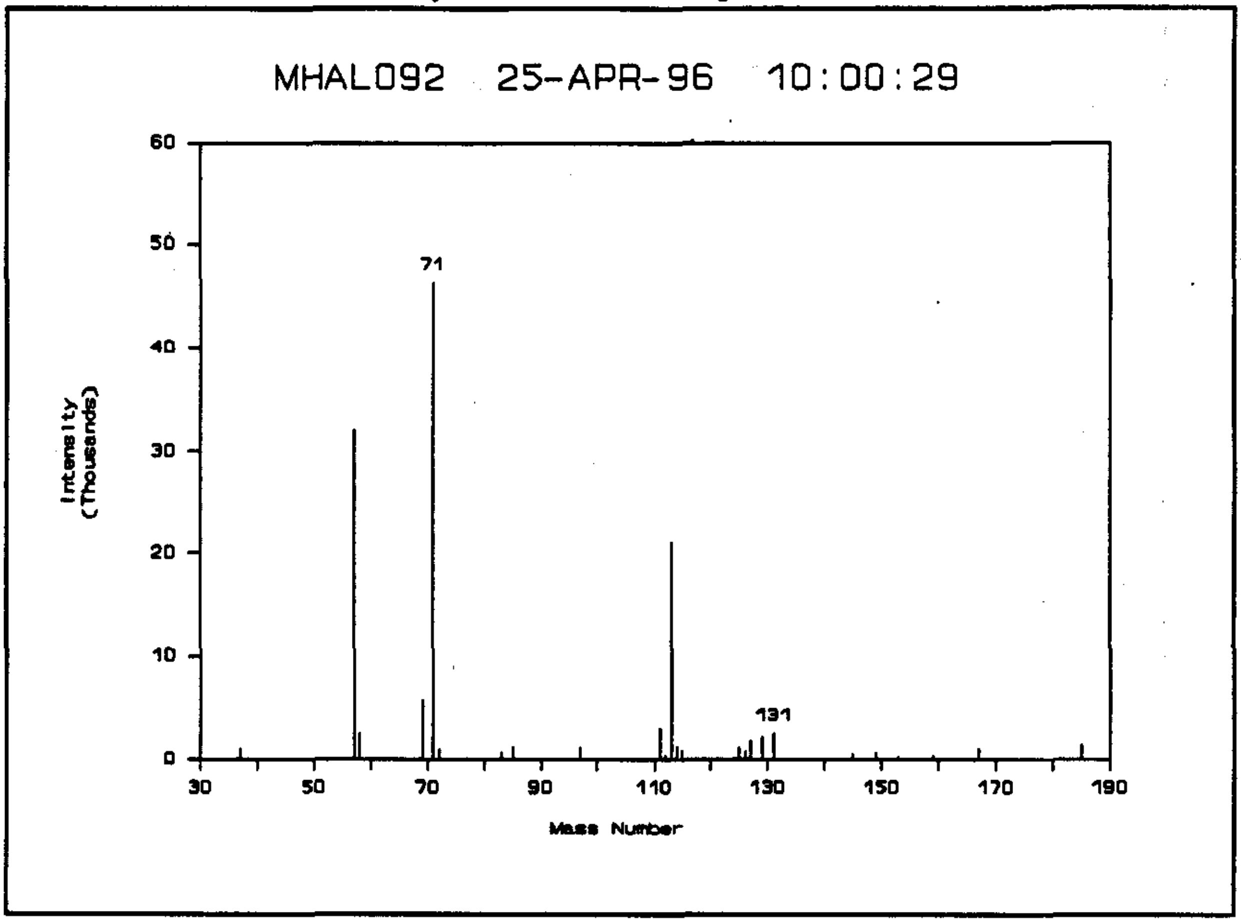

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FIGURE 15b
Daughter Ion Spectrum (m/z = 113) at Pit 1
Halby Chemical Site, Wilmington, DE

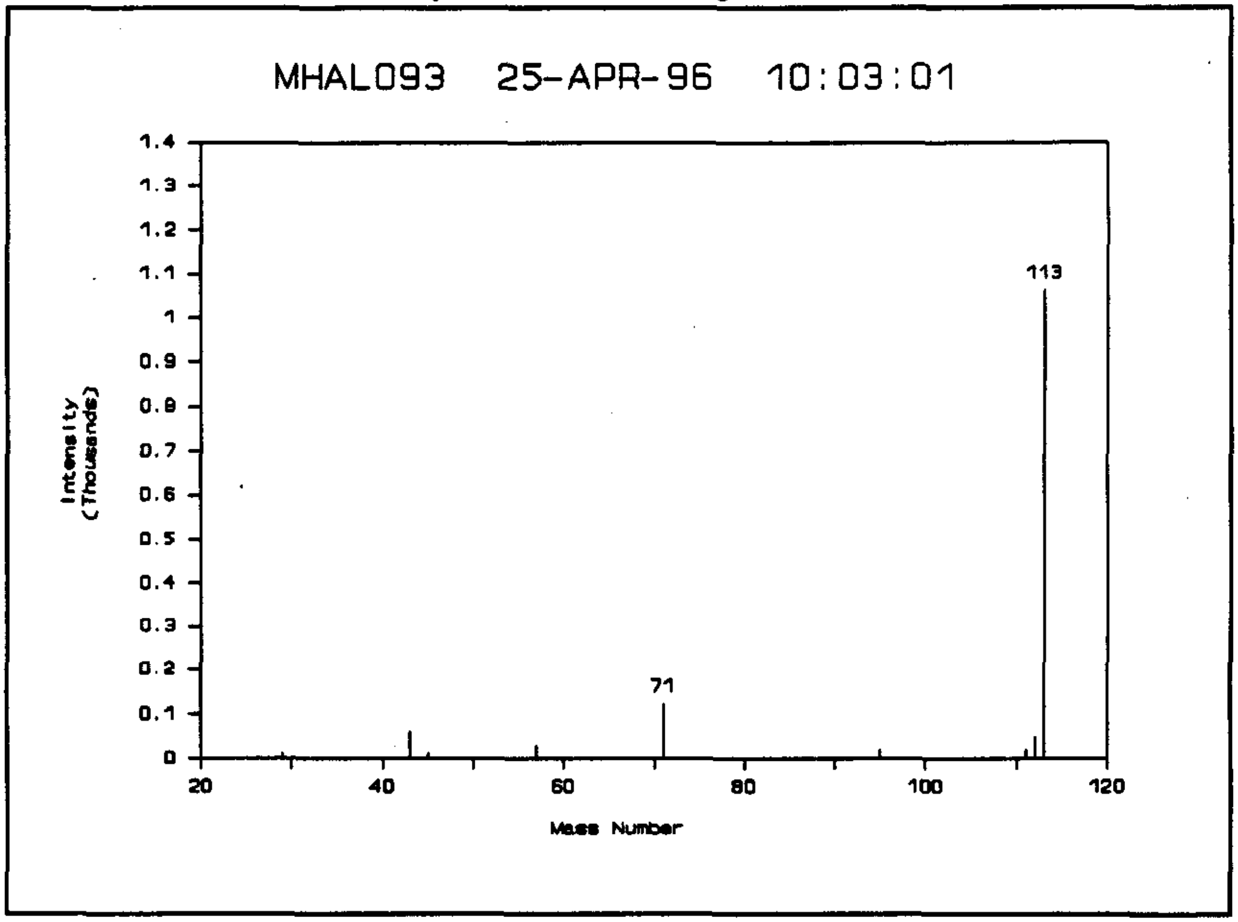

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FIGURE 15c
Daughter Ion Spectrum (m/z = 113) at Pit 1
Halby Chemical Site, Wilmington, DE

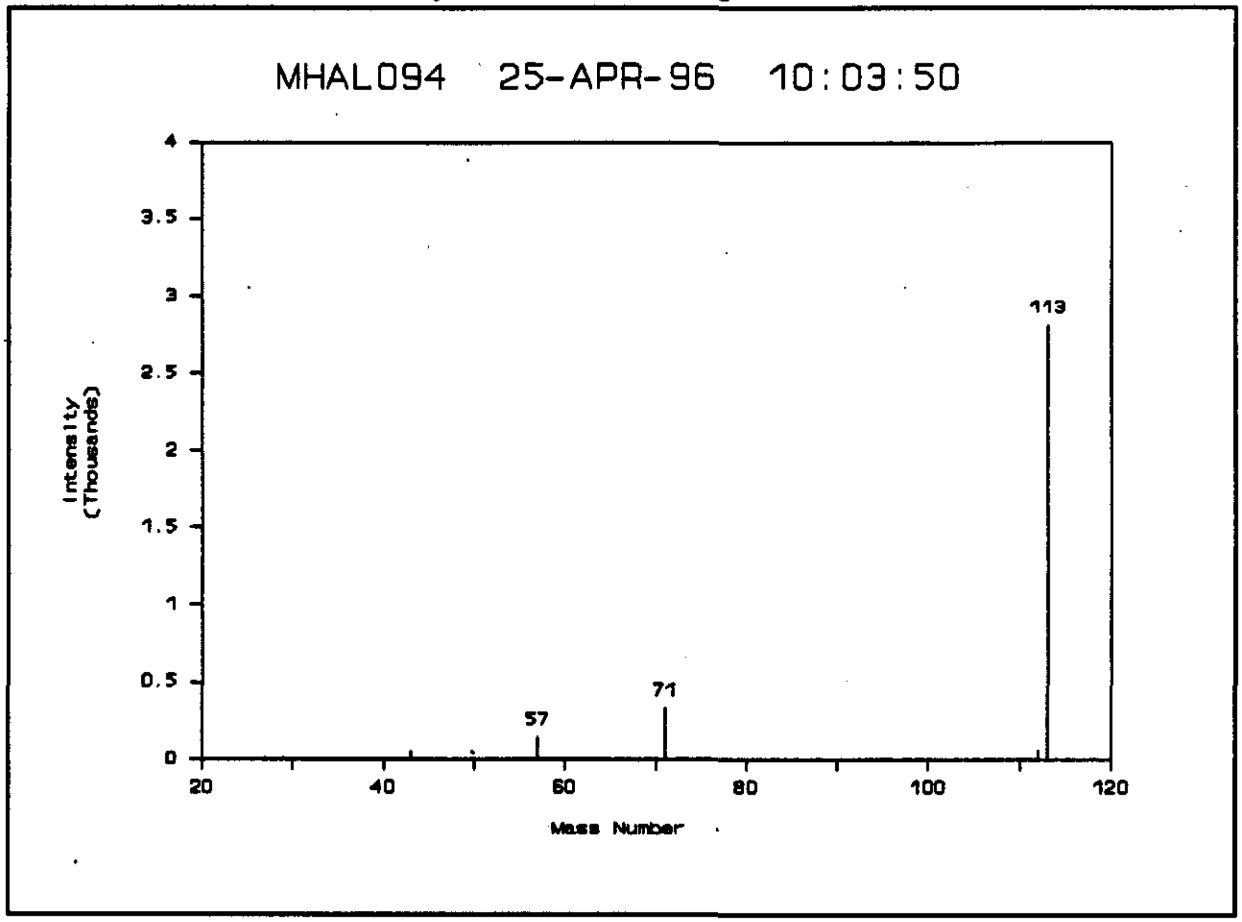

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FIGURE 15d
Background Subtracted Parent Ion Spectrum at Pit 1
Halby Chemical Site, Wilmington, DE

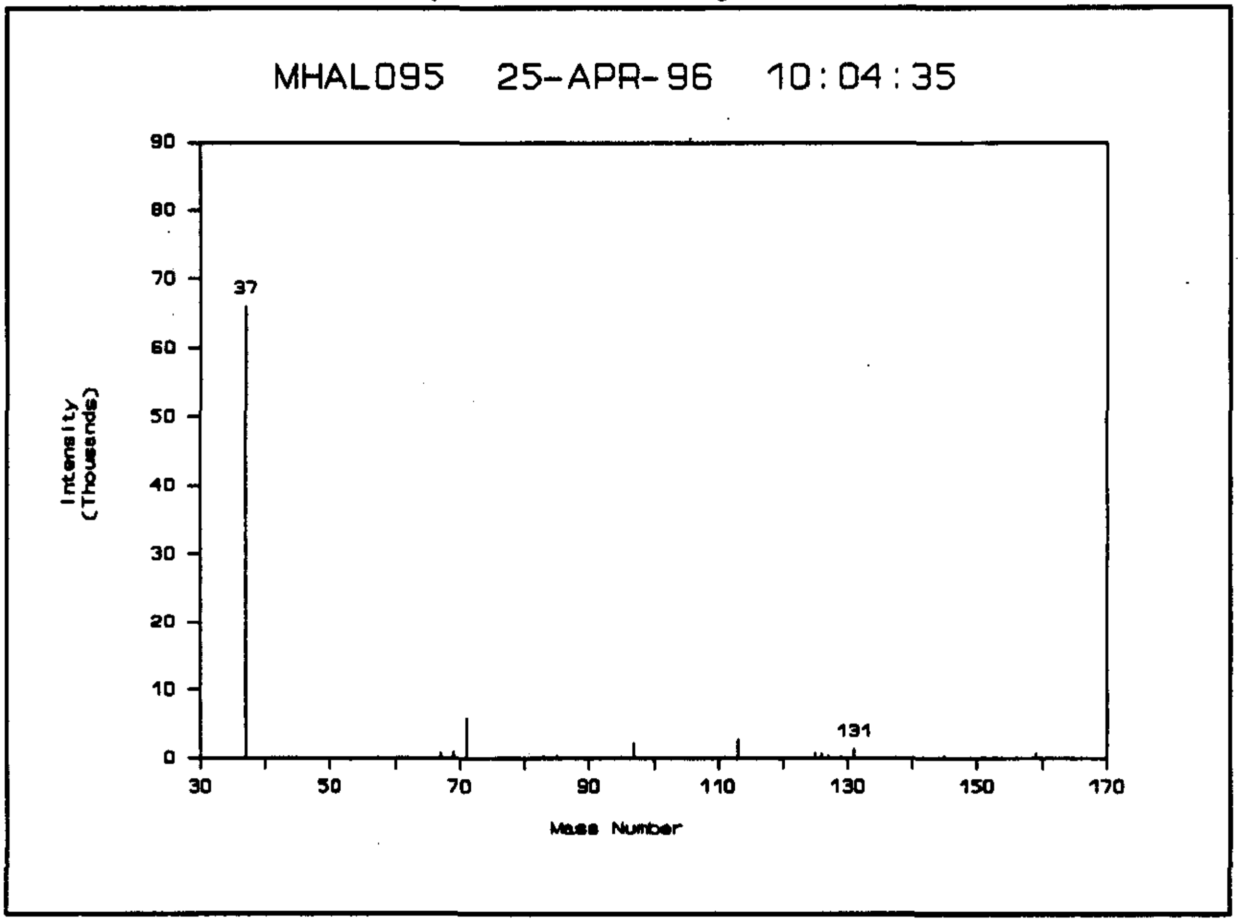

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FIGURE 15e
Background Subtracted Parent Ion Spectrum at Pit 1
Halby Chemical Site, Wilmington, DE

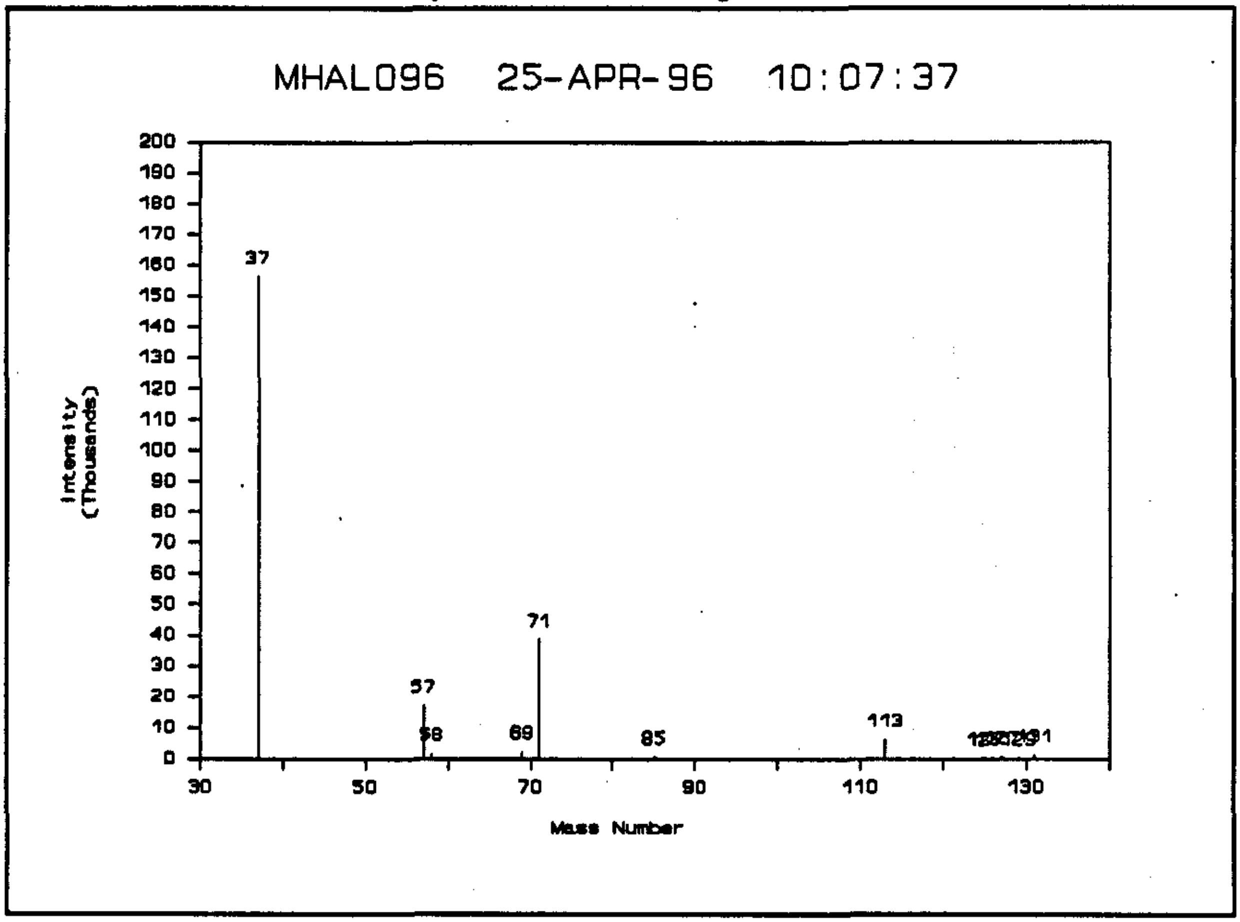

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FIGURE 15f
Background Subtracted Parent Ion Spectrum at Pit 1
Halby Chemical Site, Wilmington, DE

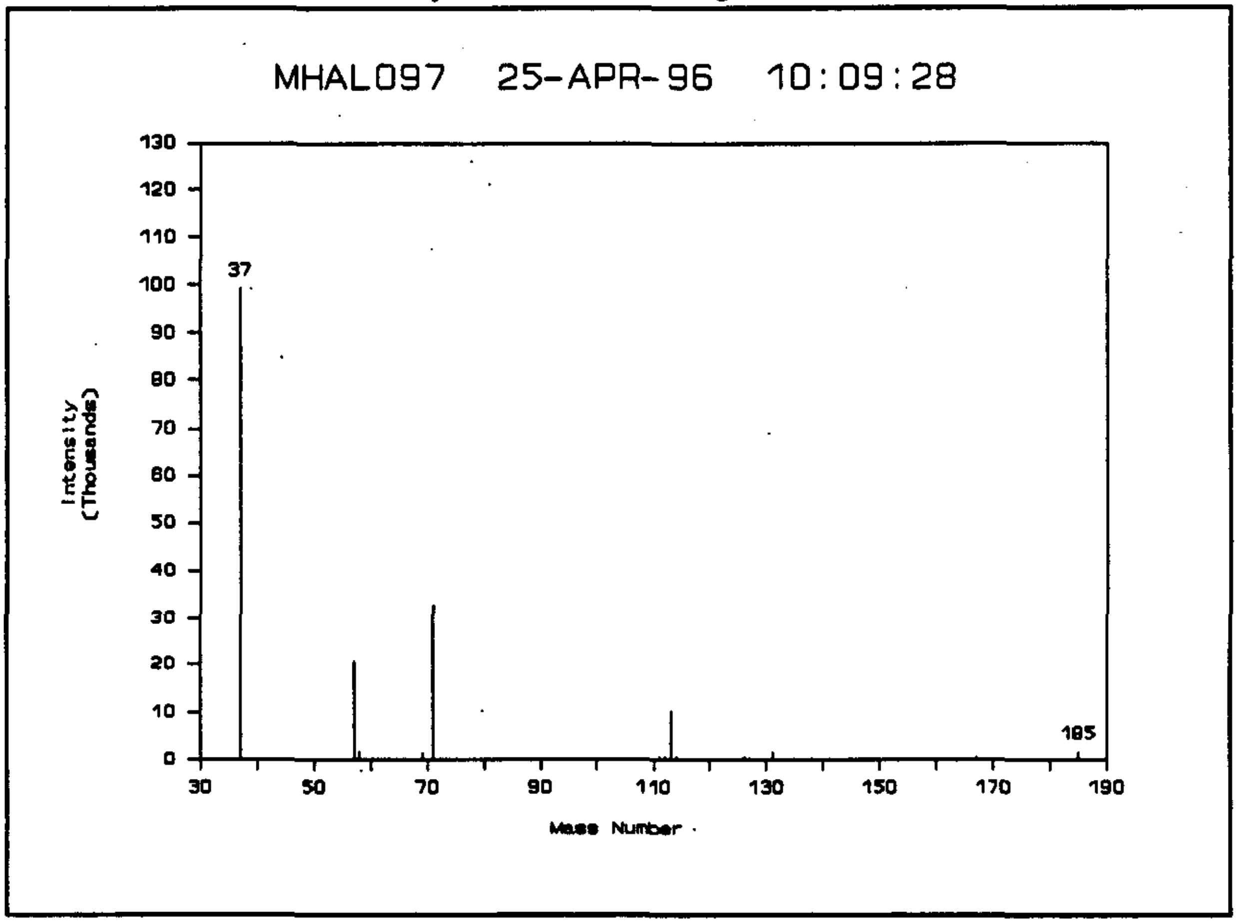

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FIGURE 15g
Background Subtracted Parent Ion Spectrum at Pit 1
Halby Chemical Site, Wilmington, DE

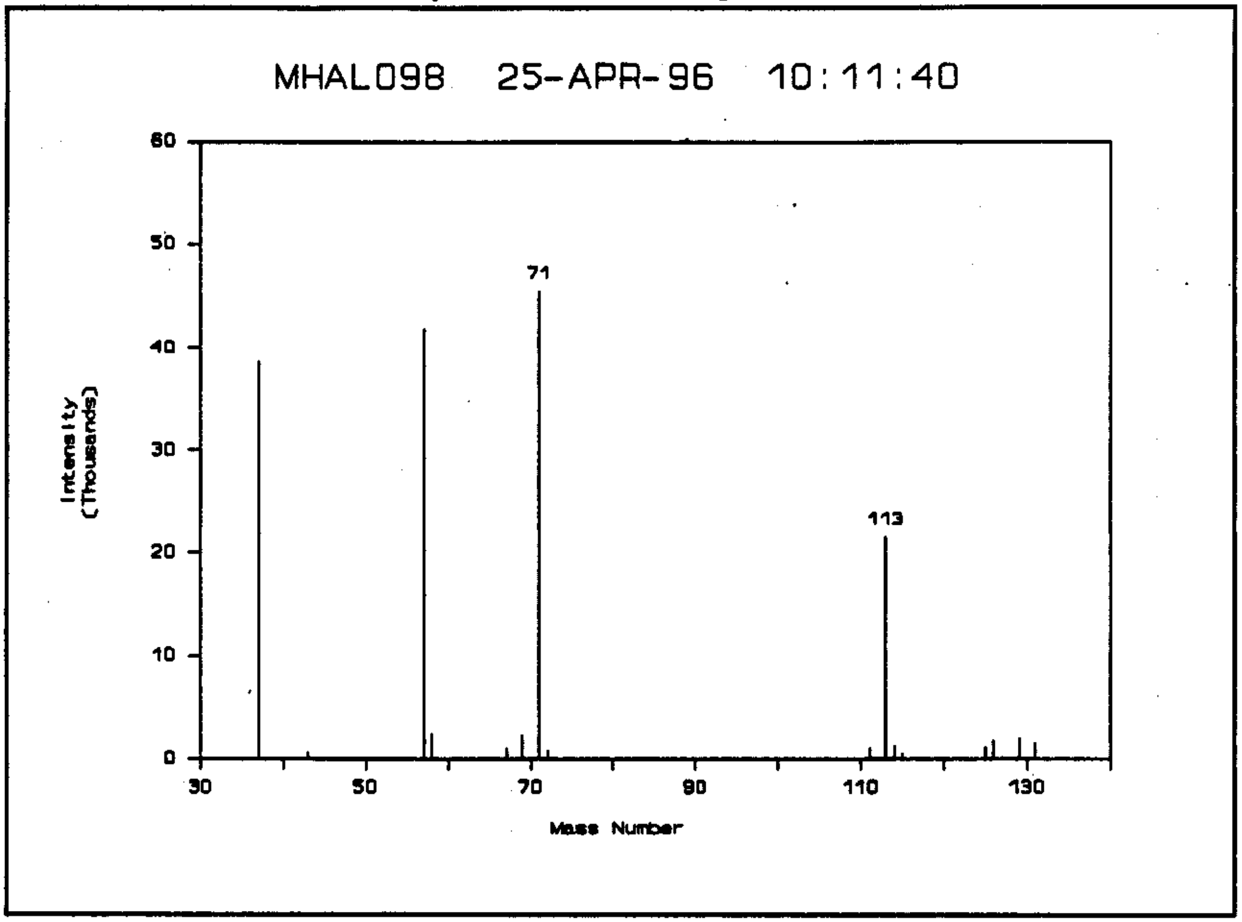

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FIGURE 15h
Daughter Ion Spectrum (m/z = 129) at Pit 1
Halby Chemical Site, Wilmington, DE

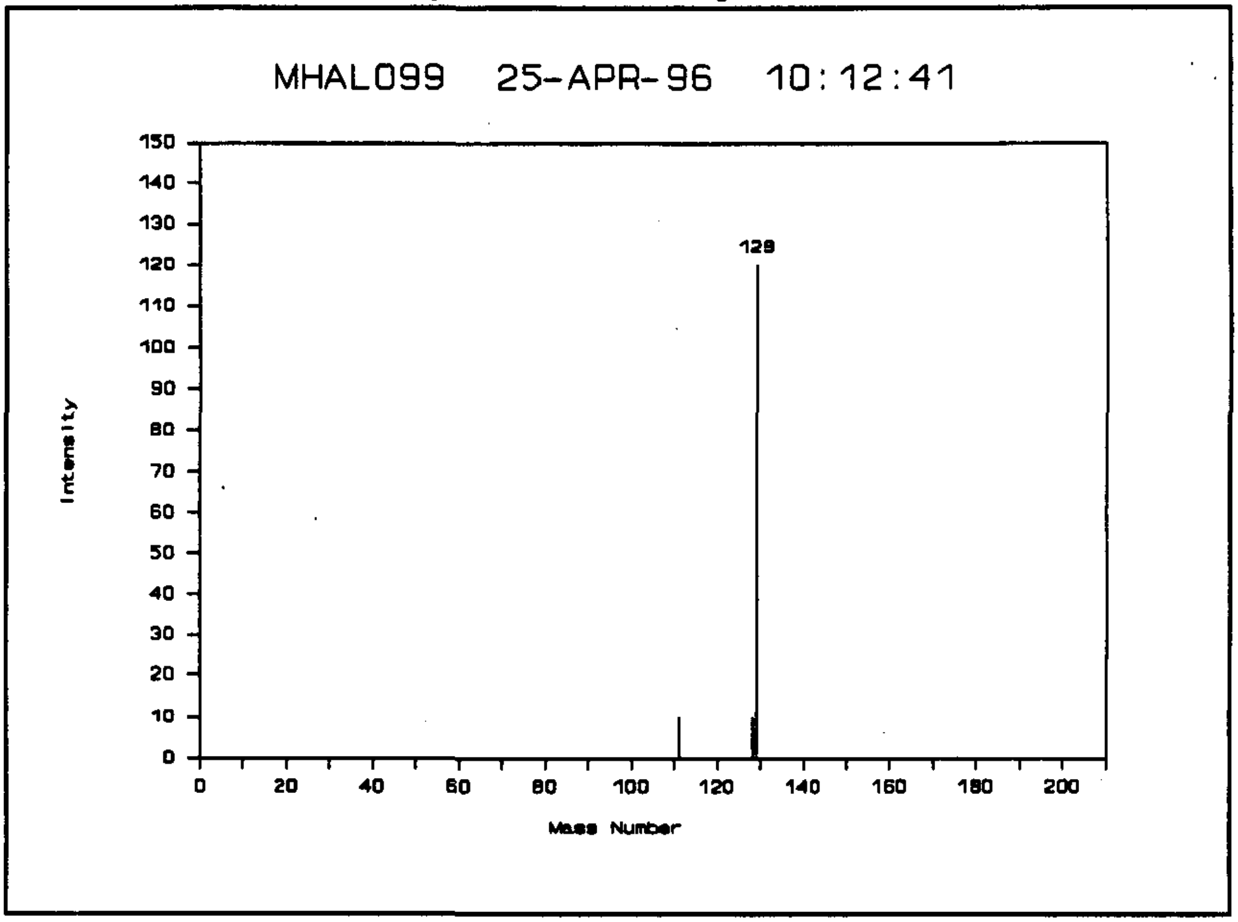

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FIGURE 15i
Background Subtracted Parent Ion Spectrum at Pit 1
Halby Chemical Site, Wilmington, DE

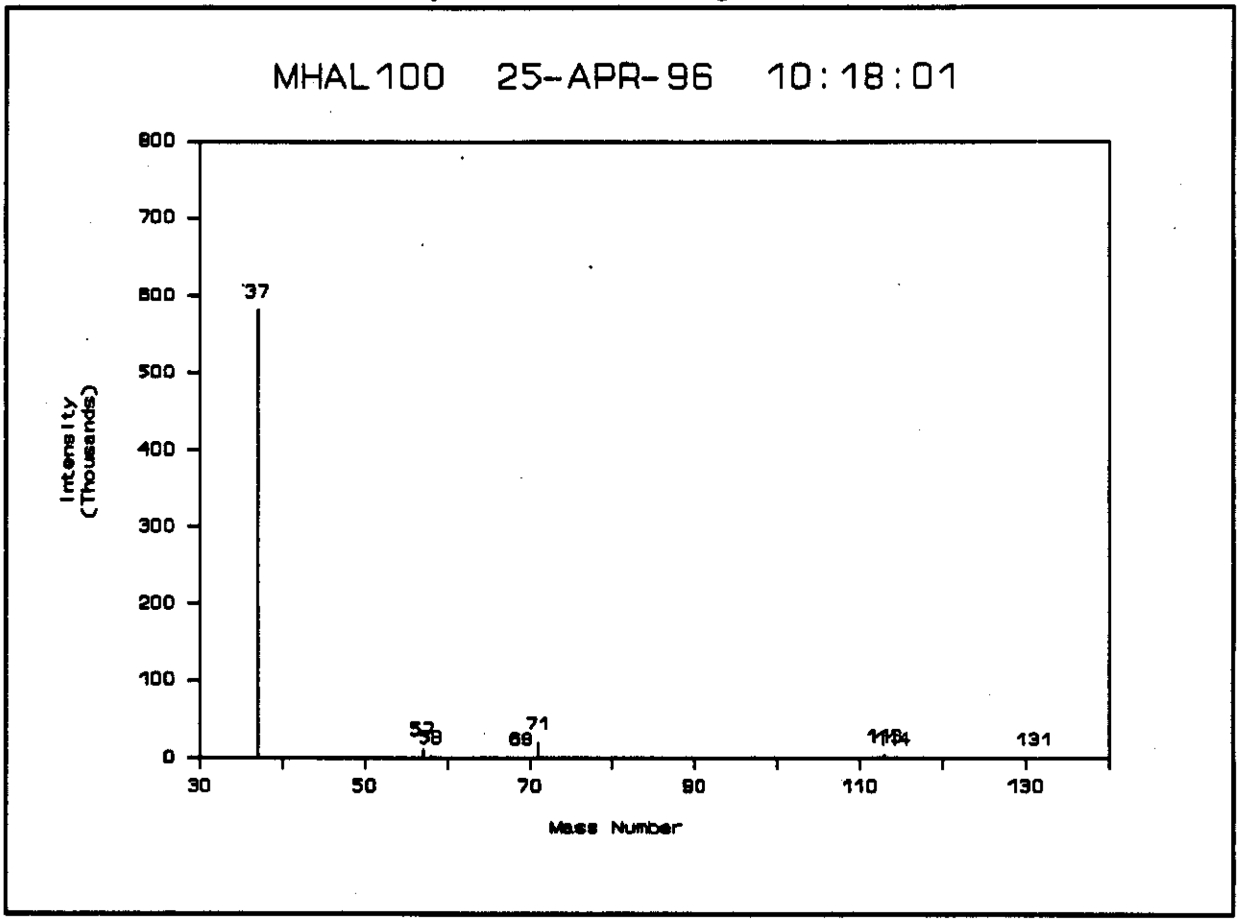

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FIGURE 15j
Background Subtracted Parent Ion Spectrum at Pit 1 - Benzene Chemical Ionization
Halby Chemical Site, Wilmington, DE

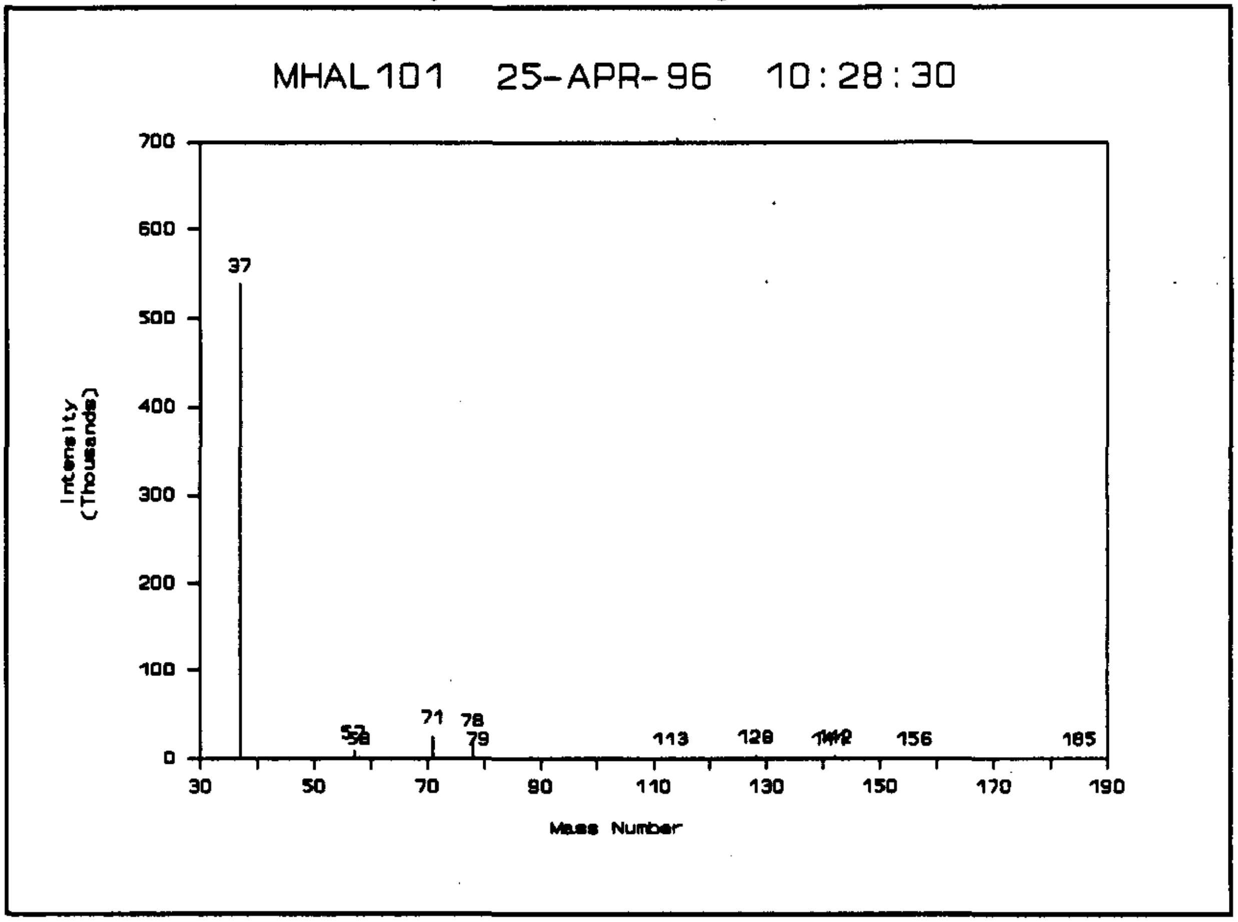

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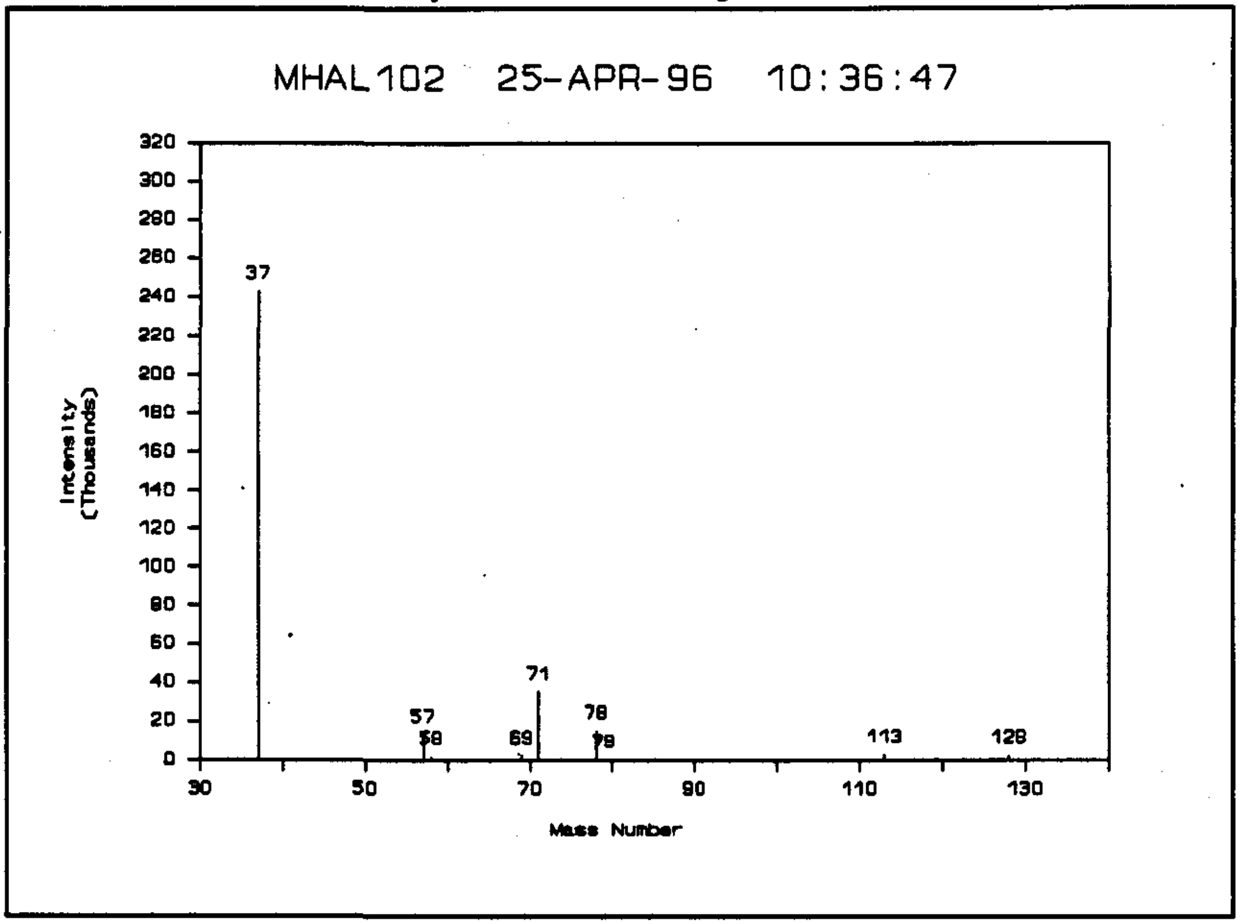
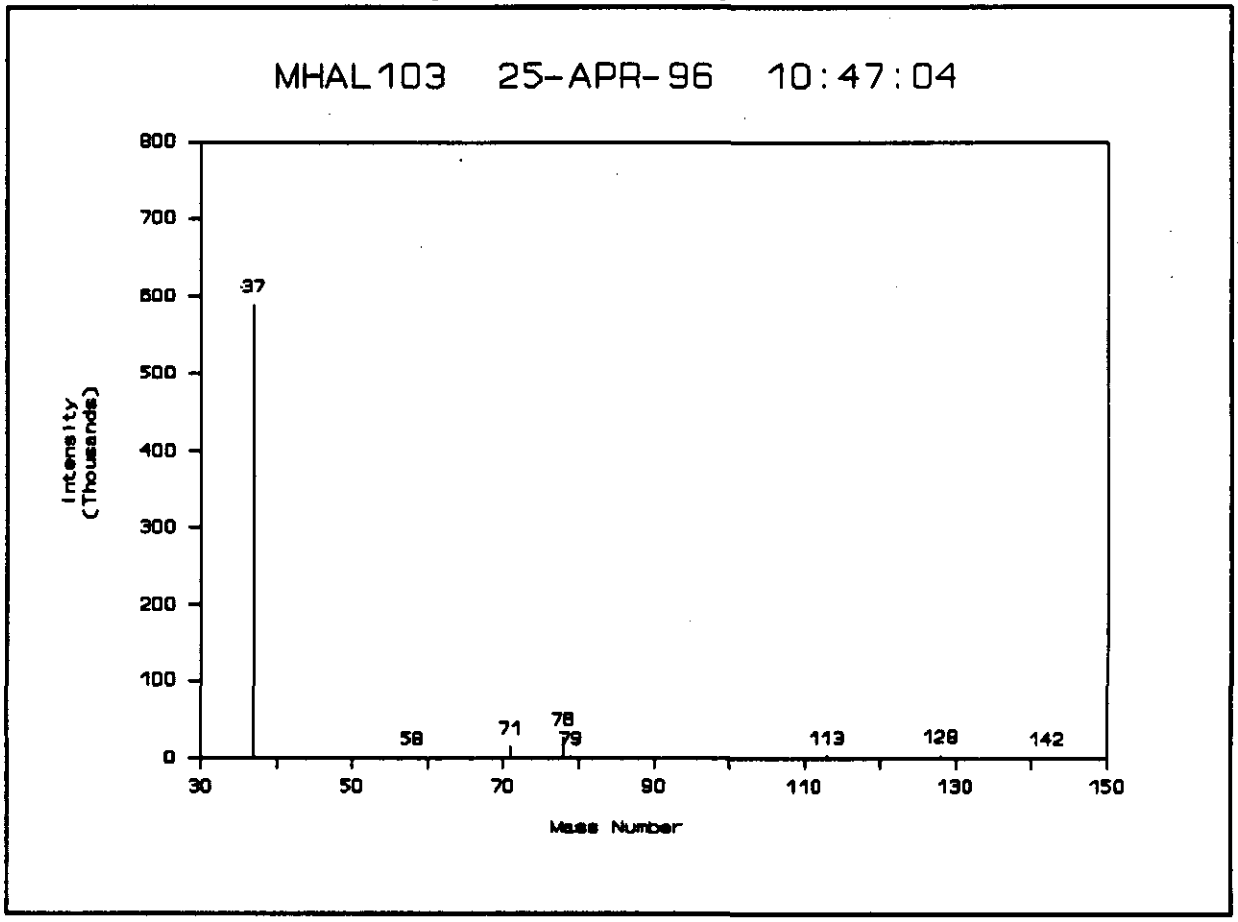
FIGURE 15k
Background Subtracted Parent Ion Spectrum at Pit 1 - Benzene Chemical Ionization
Halby Chemical Site, Wilmington, DE



\170\DEL\AI\9607\AI1170

FIGURE 151
Background Subtracted Parent Ion Spectrum at Pit 1
Halby Chemical Site, Wilmington, DE



\170\DEL\AI\9607\AI1170

FIGURE 15m
Background Subtracted Parent Ion Spectrum at Pit 1
Halby Chemical Site, Wilmington, DE

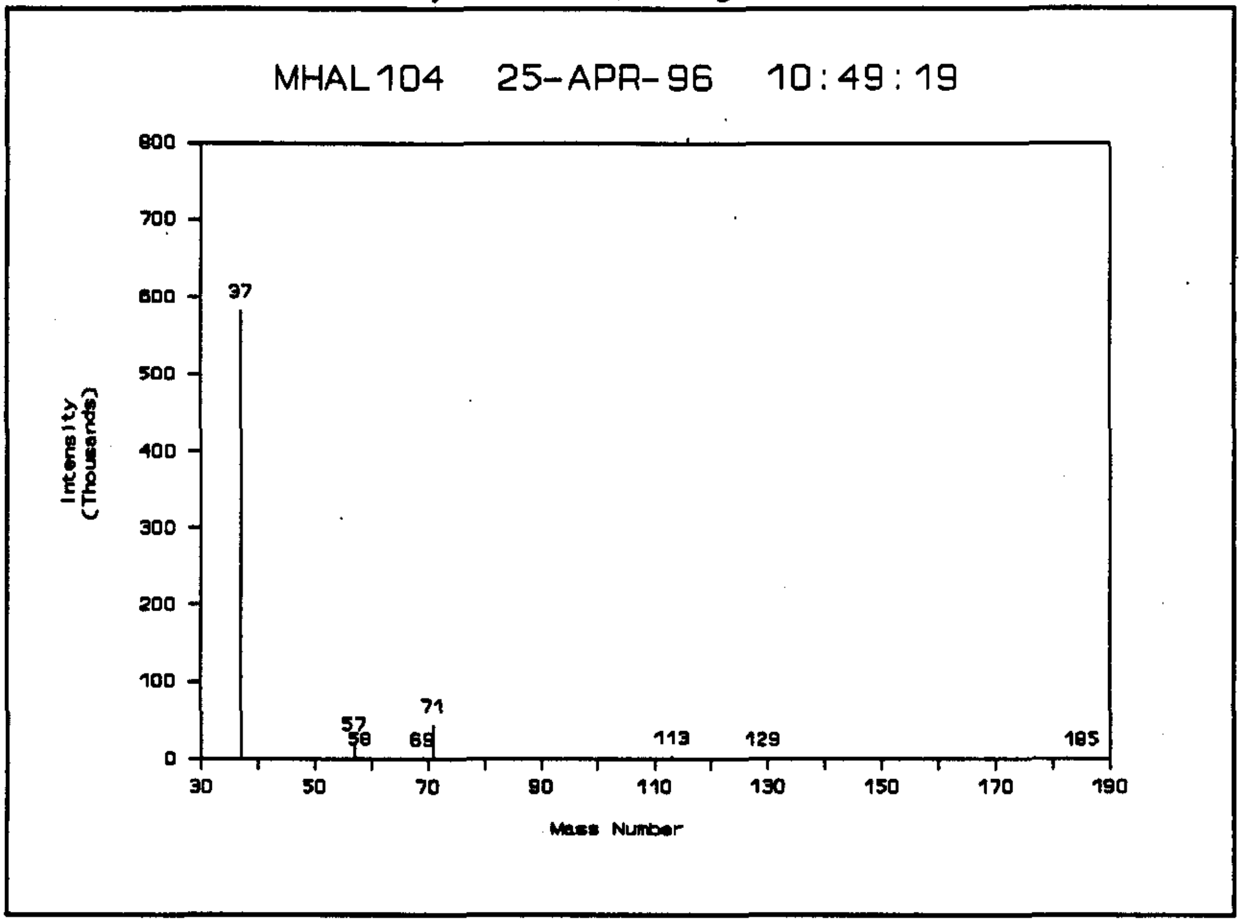


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FIGURE 15n
Background Subtracted Parent Ion Spectrum at Pit 1
Halby Chemical Site, Wilmington, DE

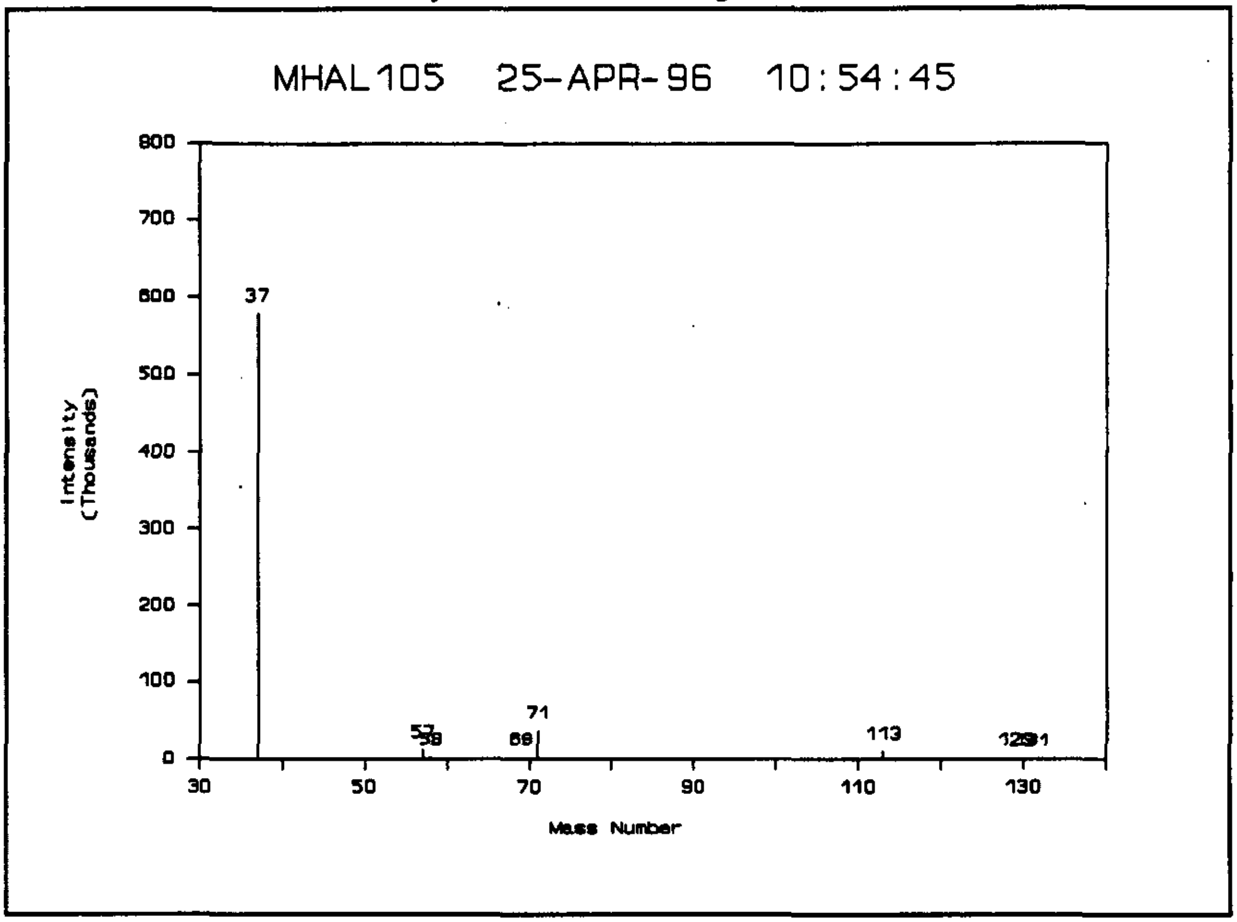

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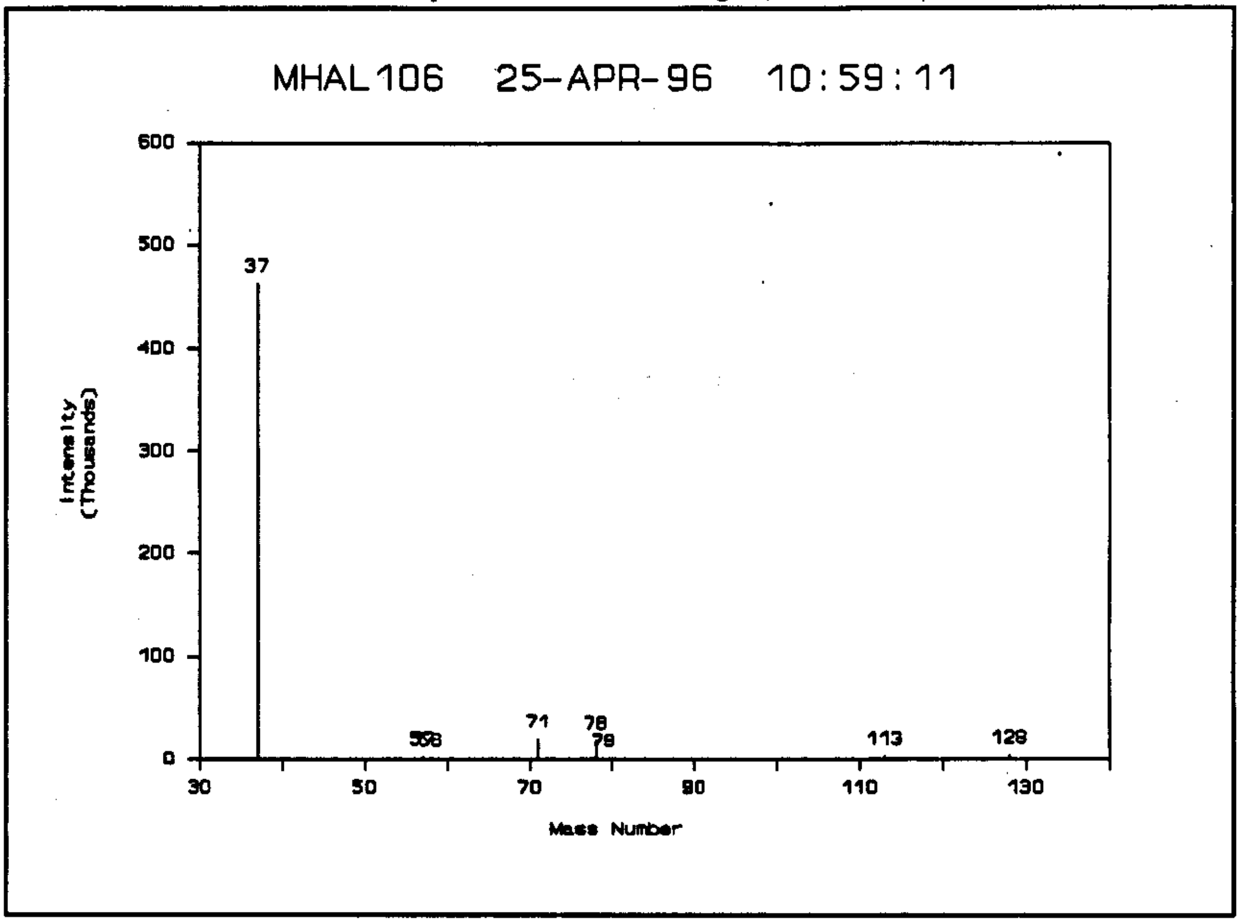
FIGURE 15o
Background Subtracted Parent Ion Spectrum at Pit 1 - Benzene Chemical Ionization
Halby Chemical Site, Wilmington, DE



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Appendices

Appe es

Appendix

Cylinder Certification
FINAL ANALYTICAL TAGA REPORT
HALBY CHEMICAL SITE
WILMINGTON, DE

JULY 1996

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MATHESON GAS PRODUCTS, INC.
932 PATERSON PLANK ROAD
EAST RUTHERFORD, NJ 07073

DATE: 9/14/93

INFO THAT YOU REQUESTED ON CYLINDER #SX-22629 WHICH WAS ON YOUR PO #08-71206-BALANCE OUR REF. 101-70279. FOLLOWING IS INFO I FOUND IN OUR FILES OF 1991.

SX-22629

22 PPM	BENZENE
22 PPM	TRANS 1,2 DICHLOROETHYLENE
26 PPM	TETRACHLOROETHYLENE
23 PPM	TOLUENE
25 PPM	TRICHLOROETHYLENE
21 PPM	VINYL CHLORIDE
11 PPM	O-XYLENE
12.7 PPM	M-XYLENE
16.7 PPM	P-XYLENE
BALANCE	NITROGEN